Lake Simcoe
Fisheries Assessment Unit

Dissolved Oxygen and Temperature Regimes for Lake Simcoe 1984-1986

Report 1987-4

Ontario
Ministry of Natural Resources
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Dissolved Oxygen and Temperature Regimes for Lake Simcoe 1984-1986

by

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Report 1987-3

ABSTRACT

Temperature and dissolved oxygen data were collected from 3 stations on Lake Simcoe from May until lake turnover, sometime in October, 1984 to 1986. Dissolved oxygen levels in the entire hypolimnion were less than 3 mg/l by late September, and less than 2 mg/l by early October, at two of the stations, and ranged from 2-6 mg/l from late August until fall turnover at the third station. Dissolved oxygen depletion rates were statistically equal at the 3 sites over the 3 years, but the mean hypolimnetic temperatures at the shallowest station were higher than at the 2 deeper stations every year. Multi-year comparisons of depletion rates and mean hypolimnetic temperatures from 1978 to 1986 were made, and some statistically significant differences found. The early warming of bottom waters at the shallower station, and the effectiveness of using mean hypolimnetic temperature when relating dissolved oxygen and temperature data are discussed.

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1.0 INTRODUCTION

Collection of dissolved oxygen and temperature data has been carried out regularly at two stations, K45 and K42 since 1975. Until 1984 this was done by staff from the Lake Simcoe Fisheries Assessment Unit (LSFAU) and previous to that by the Ministry of the Environment. From 1984 to 1986 the LSFAU, collected the data. Results are detailed in several reports (Evans, 1978; DesJardine and Lawrence, 1978; DesJardine, 1980; Dobson et al, 1980; Willox, 1982; Humber, 1985; Lake Sub-group, 1985; Waring, 1986). A third, shallower station, S15, was sampled by the LSFAU in 1980, 1981, for a short period from August to October 1982, and from 1984 to 1986. The S15 data were reported prior to 1984 only for 1980, by Willox (1982). The three stations have been sampled regularly by LSFAU staff since 1984, one of whom is provided by the M.O.E.

Previous reports on the dissolved oxygen and temperature regimes of Lake Simcoe have discussed in detail the biological effects of depressed hypolimnetic oxygen levels during summer stratification, especially with regard to lake whitefish, Coregonus clupeaformis, and lake trout, Salvelineus namaycush. (Evans, 1978; DesJardine and Lawrence, 1978; DesJardine, 1980; Willox, 1982; Waring, 1986). This report summarizes and discusses the dissolved oxygen and temperature data collected at the three stations, K45, K42, and S15 from 1984 to 1986. Comparisons of dissolved oxygen depletion rates and mean hypolimnetic temperatures at K45 from 1978 to 1986 are made. The use of mean hypolimnetic temperature as a measure of temperature when relating it to dissolved oxygen is discussed.

2.0 MATERIALS AND METHODS

Lake Simcoe lies entirely in the glaciated Trenton limestone formation of Southern Ontario. The lake has a shoreline of 732 km and an area of 725 km^2 which is comprised of a single basin and two well defined bays (Figure 1). The basin slopes from east to west and has a mean and maximum depth of 17.1 and 40 m respectively. (Waring, 1986)

From May to October of 1984-1986, secchi disc readings, dissolved oxygen levels and temperature data were collected weekly, when weather permitted, from 3 stations: K45, located in the main basin of the lake, 6.5 km northeast of Big Bay Point (30m) in 1984 and 1985, and 6.4 km northeast of Oro Beach (35m) in 1986; K42, located in Kempenfelt Bay midway between Shanty Bay and Bear Point (39m); and S15, located 4.2 km north-northwest of Jackson's Point (20m). The location of K45 was changed in 1986 in order to concur with the Ministry of the Environment station K45 location. Sampling schedules are given in Table 1.

Dissolved oxygen and temperature values were obtained at 1 metre intervals from surface to 1 m above bottom using a YSI model 54 oxygen meter equipped with a model 5739 probe. In 1984, the YSI meter was calibrated at each station using the saturated air calibration method. In 1985, the meter was calibrated at each station to a surface water sample, collected using the Van Dorn water sampler. The dissolved oxygen was determined using the azide modification of the Winkler method for dissolved oxygen concentration (Franson et al 1975). In 1986, the YSI meter was calibrated at the office before sampling using the Winkler method. The Winkler method was used in 1985 and 1986 instead of the saturated air calibration method to

Figure 1: Lake Simcoe limnological sampling stations, 1984 to 1986

conform with the methods used by the Ministry of the Environment, and because it was felt to be more accurate.

Mean hypolimnetic water temperature and dissolved oxygen depletion rates were calculated using values at 5m above bottom at K45 and K42, and 3m above bottom at S15. The bottom value at each station varied daily within a few metres of the maximum depth, so data was not obtained at a constant depth. Upper and lower metalimnion boundaries were determined based on changes of greater than 1°C per meter (Birge, 1897). Days from June 1 were calculated including June 1 (ie. June 30 = 30 days) as in previous reports (DesJardine and Lawrence, 1978; DesJardine, 1980; Willox, 1982; Waring, 1986). Fall turnover was determined to be the date on which a sharp rise in temperature at 5m above bottom (3m at S15) occurred. This date varied between sites and years.

For various reasons some of the data collected was omitted from graphs, diagrams, and statistical calculations. This is detailed in Table 2.

All statistical analyses used in this report incorporate a 5% significance level. Values used in the analyses of variance and covariance are appendixed.

Table 1: Sampling schedules for K45, K42 and S15, 1984-1986.

1984			1985			1986		
Date		Station Sampled	Date		Station Sampled	Date		Station Sampled
May	17	K45,K42,S15	May	31	S15	May	16	S15
	24	K45, S15					21	K45,K42,S15
	31	K45,K42,S15					26	K45,K42,S15
June	6	K45,K42,S15	June	5	K45,K42	June	4	K45,K42,S15
	12	K45,K42,S15		12	K45,K42,S15		9	K45,K42,S15
	20	K45,K42,S15		20	K45,S15		19	K45,K42,S15
	26	K45,K42,S15		27	K45,K42,S15			
July	3	K45,K42,S15	July	4	K45,K42,S15	July	2	K45,K42,S15
	9	K45,K42,S15		9	K45,K42,S15		15	K45,K42,S15
	23-25	K45,K42,S15		17	K45,K42,S15		21	K45,K42,S15
				24	K45,K42,S15		28	K45,K42,S15
August	7	K45,K42,S15	August	2	K45,K42,S15	August	5	K45,K42,S15
	14	K45,K42,S15		5	K45,K42,S15		12	K45,K42,S15
	21	K45,K42,S15		14	K45,K42,S15		19	K45,K42,S15
	28	K45,K42,S15		21	K45,K42,S15			
September	6	K45,K42,S15	September	6	K45,K42,S15	September	2	K45,K42,S15
	12	K45,K42,S15		16	K45,K42,S15		15	K45,K42,S15
	21	K45,K42,S15		25	K45,K42,S15		23	K45
	27	K45,K42,S15						
October	2	K45,K42,S15	October	3	K45,K42,S15	October	2	K45,K42,S15
	16	K45		11	K45,K42,S15			

Table 2: Data omitted from statistical analyses, graphs and diagrams

Year	Date	Station	Reason for Omission
1984	August 28	S15	Dissolved oxygen levels at 3m above bottom were uncharacteristically low; values below this were significantly higher; it appeared the YSI probe had been in organic bottom material affecting the readings
	September 6	S15	Cable of YSI meter on a large angle, no reason given,therefore profile data was inaccurate
1985	June 12	K45,K42,S15	Very windy day, cable of YSI meter on large angle so profile data inaccurate
	June 27	K42	A bottom value of 44m was given; this was too great a variation from the maximum depth value of 39m. YSI cable may have been on an angle
	July 24	K42	No bottom was apparent even at 50m; a very windy day, so cable was likely on an angle
1986	June 19	K45	Unable to locate K45 marker so location estimated, profile data probably inaccurate
	August 19	K45	Using new probe which wasn't reading correctly, therefore values invalid

3.0 RESULTS

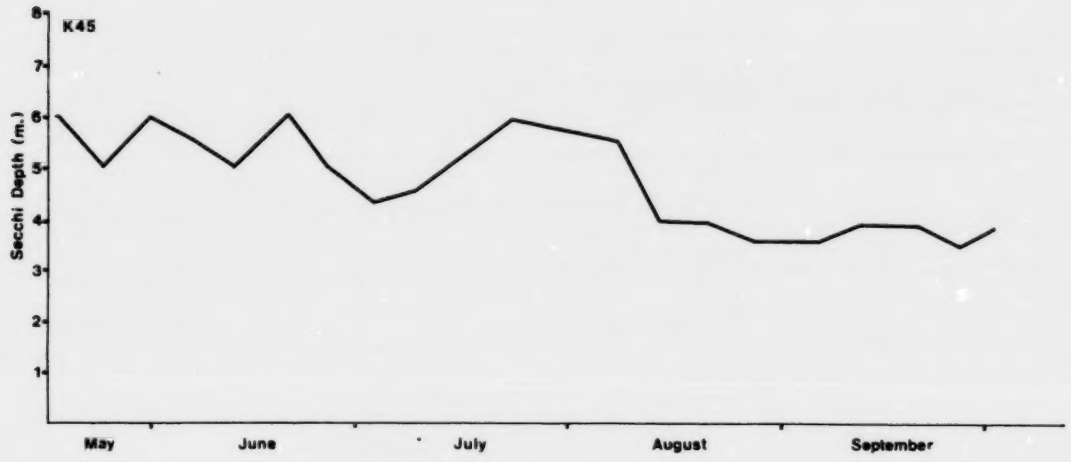
3.1 Secchi Disc Readings

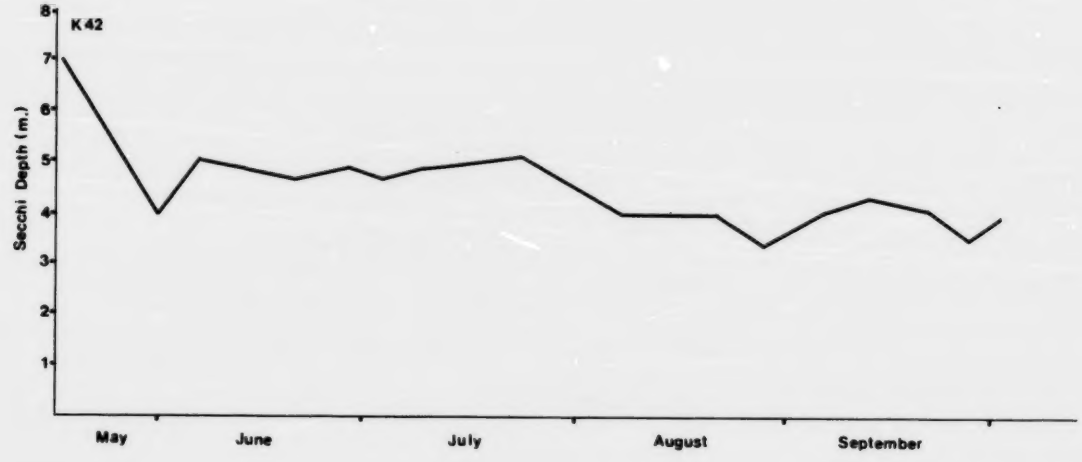
Mean secchi disc readings show little difference between sites and years (Table 3) although these were not compared statistically. In 1984, secchi disc depths gradually decreased over the sampling period. In 1985 and 1986, values decreased until August from a peak between June and July, then rose slightly again in September. S15 showed the greatest variation in values (Figures 2-4).

Table 3: Average secchi disc readings for K45, K42 and S15, 1984-1986 (n=number of observations)

Station	Average Secchi Disc Reading (m.) + Standard Deviation			
	1984	1985	1986	Combined
K45	4.7 + .928 n = 19	4.96 + 1.017 n = 17	4.61 + 1.58 n = 17	4.755 + 1.176 n = 53
K42	4.41 + .811 n = 18	4.81 + .764 n = 15	4.62 + 1.66 n = 16	4.6 + 1.127 n = 49
S15	4.5 + .913 n = 19	4.71 + 1.104 n = 18	4.94 + 1.72 n = 17	4.707 + 1.254 n = 54
Combined	4.54 + .87 n = 56	4.821 + .963 n = 50	4.726 + 1.623 n = 50	

Figure 2: Secchi disc readings obtained on limnological sampling days at K45, K42, and S15, 1984





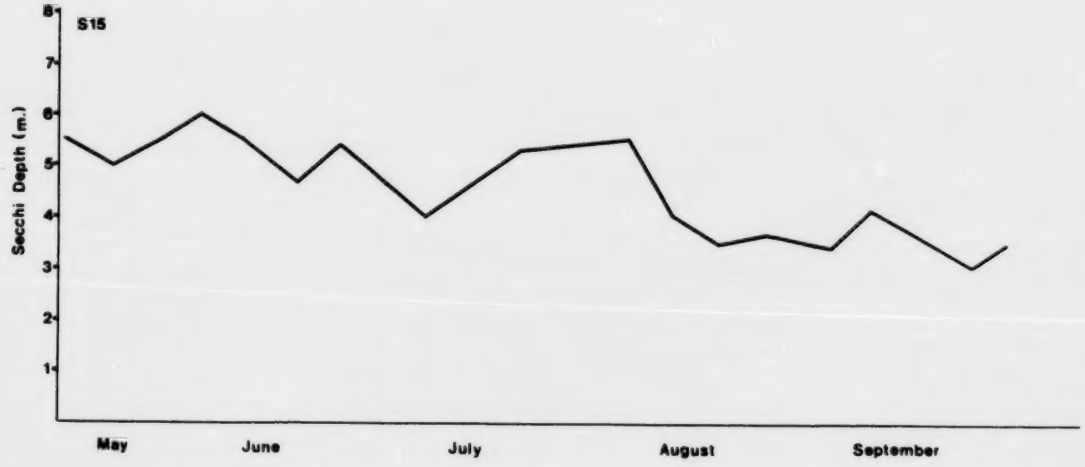


Figure 3: Secchi disc readings obtained on limnological sampling days at K45, K42, and S15, 1985

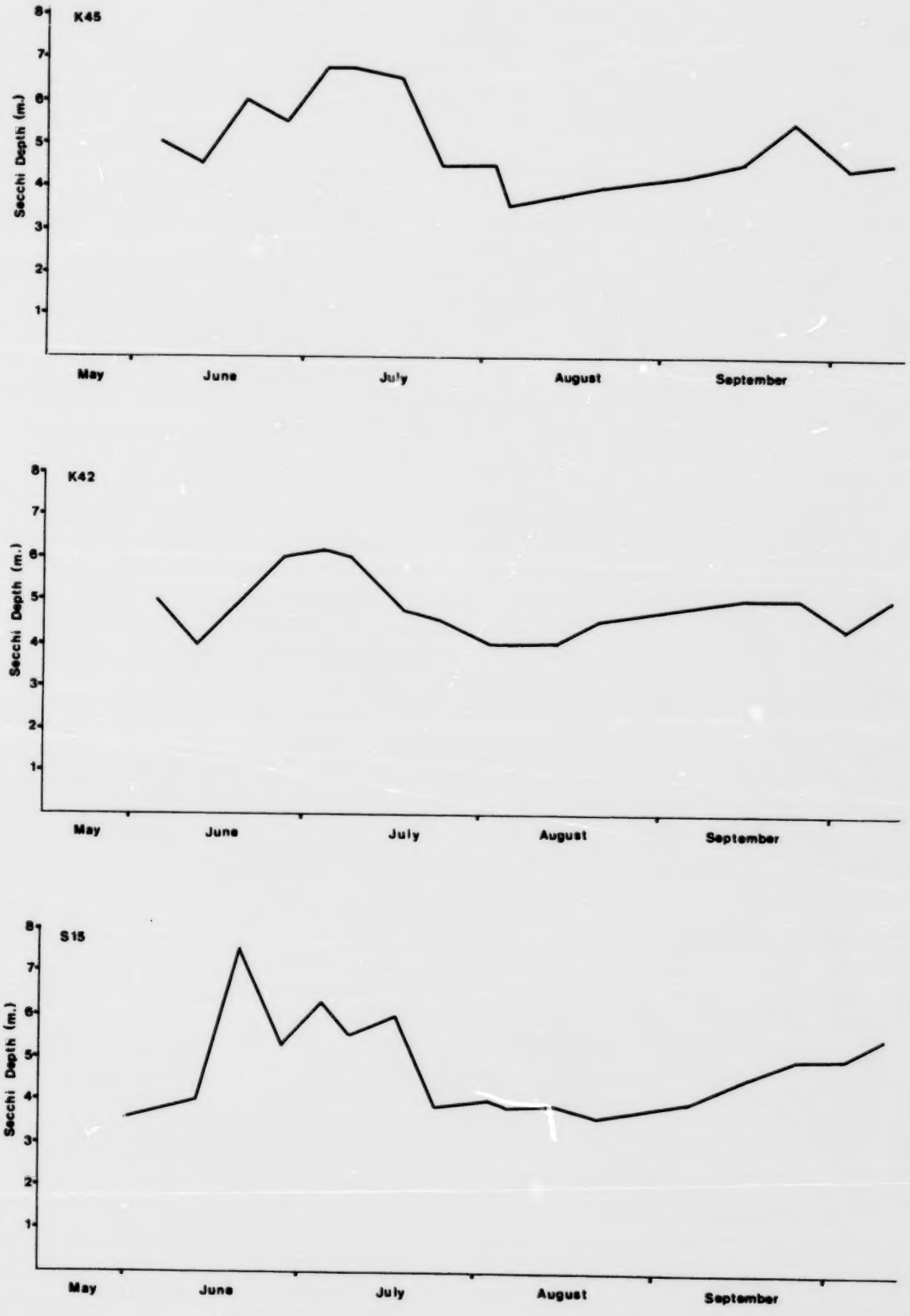
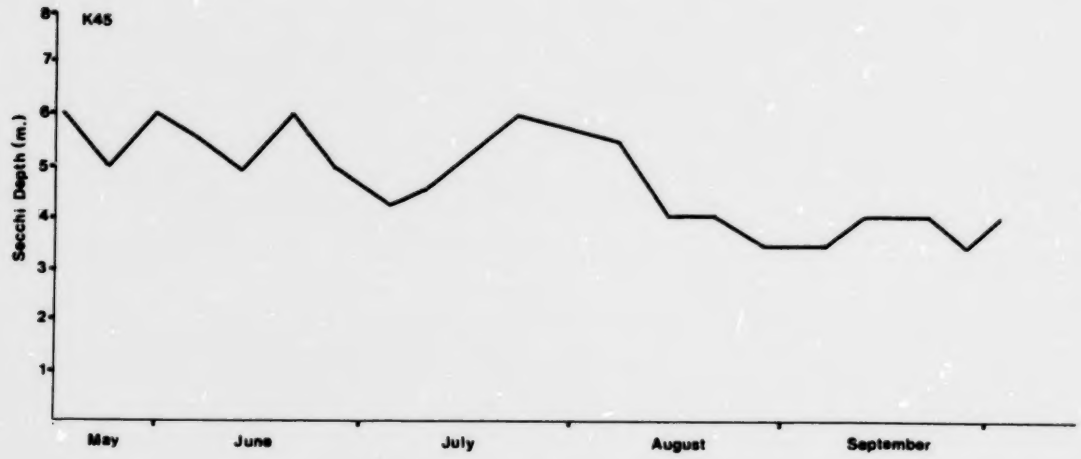
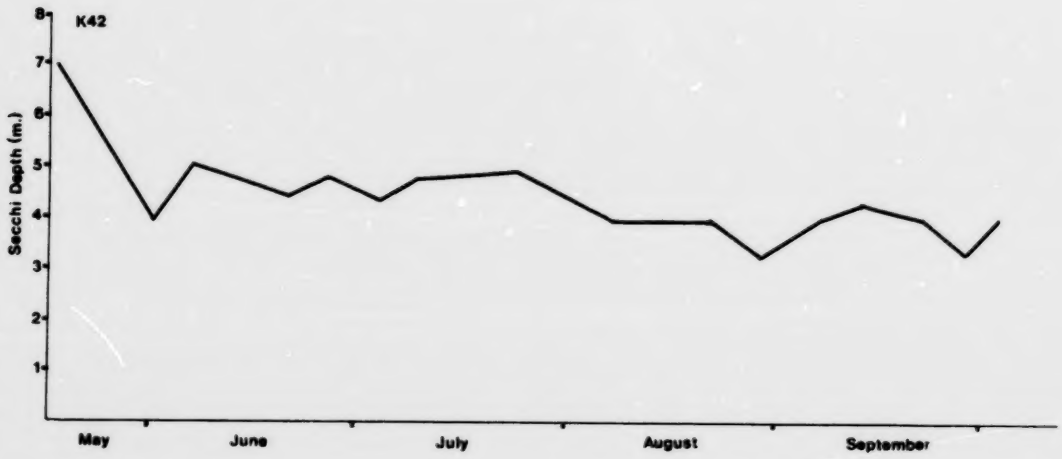
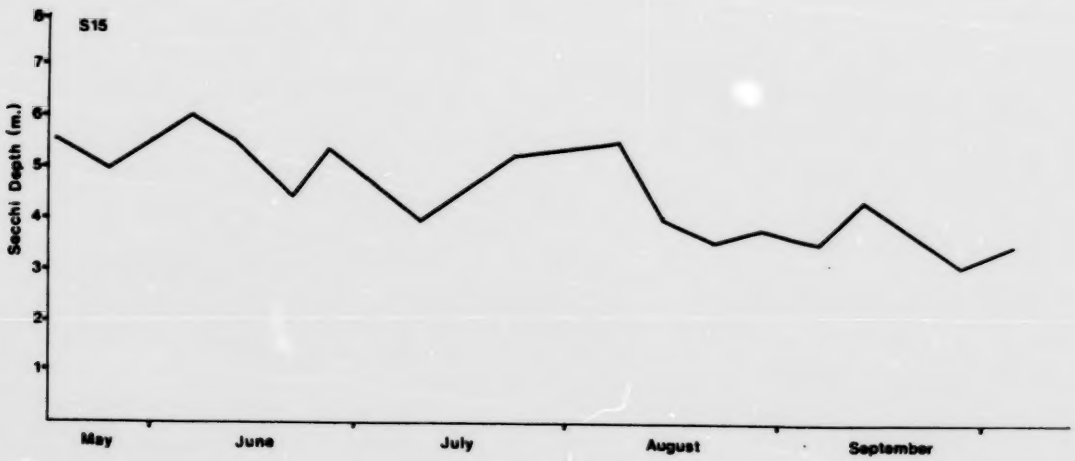


Figure 4: Secchi disc readings obtained on limnological sampling days at K45, K42, and S15, 1986







3.2 Temperature

Depth-time isotherms for the 3 sites, K45, K42,and S15 are provided for the 3 study years (Figures 5-13). These show the seasonal trends in thermal patterns.

Generally temperatures throughout the column were between 5 - 10°C through May, but in 1986 temperatures as high as 14°C were seen in late May. At K45, thermal strata first appeared in mid-June, becoming well-defined by mid-July. At K42, strata appeared in late June to early July, stabilizing for a short period of from 1 to 3 weeks between mid-July and mid-August. Strata appeared at S15 between mid-June and early July in 1984 and 1985, stabilizing by mid to late July. In 1986 poorly defined strata were evident in May and June, becoming well-defined by mid-July to mid-August. As in 1980 (Willox, 1982),strata were less defined at K42 than at other stations. At all stations strata were no longer well-defined by late August to mid-September.

Surface temperatures in 1984 rose from between 7-10°C in May to 22-24°C by mid-August, falling to 14°C by mid-October. In 1985 and 1986, early June temperatures ranged from 12-14°C, rising to 21-22°C by mid-August, falling to 13-14°C in October 1985, and to 12-16°C in October 1986. Bottom temperatures rose from between 5-8°C in May to 9-13°C in October at K45 and K42, and at S15 to 16-17°C in September, falling to 14°C in October.

Hypolimnetic temperatures generally increased over the sampling season, except at S15 in 1985 and 1986, where large fluctuations were

Figure 5: Depth-time isotherms (C) at K45, May to October 1984

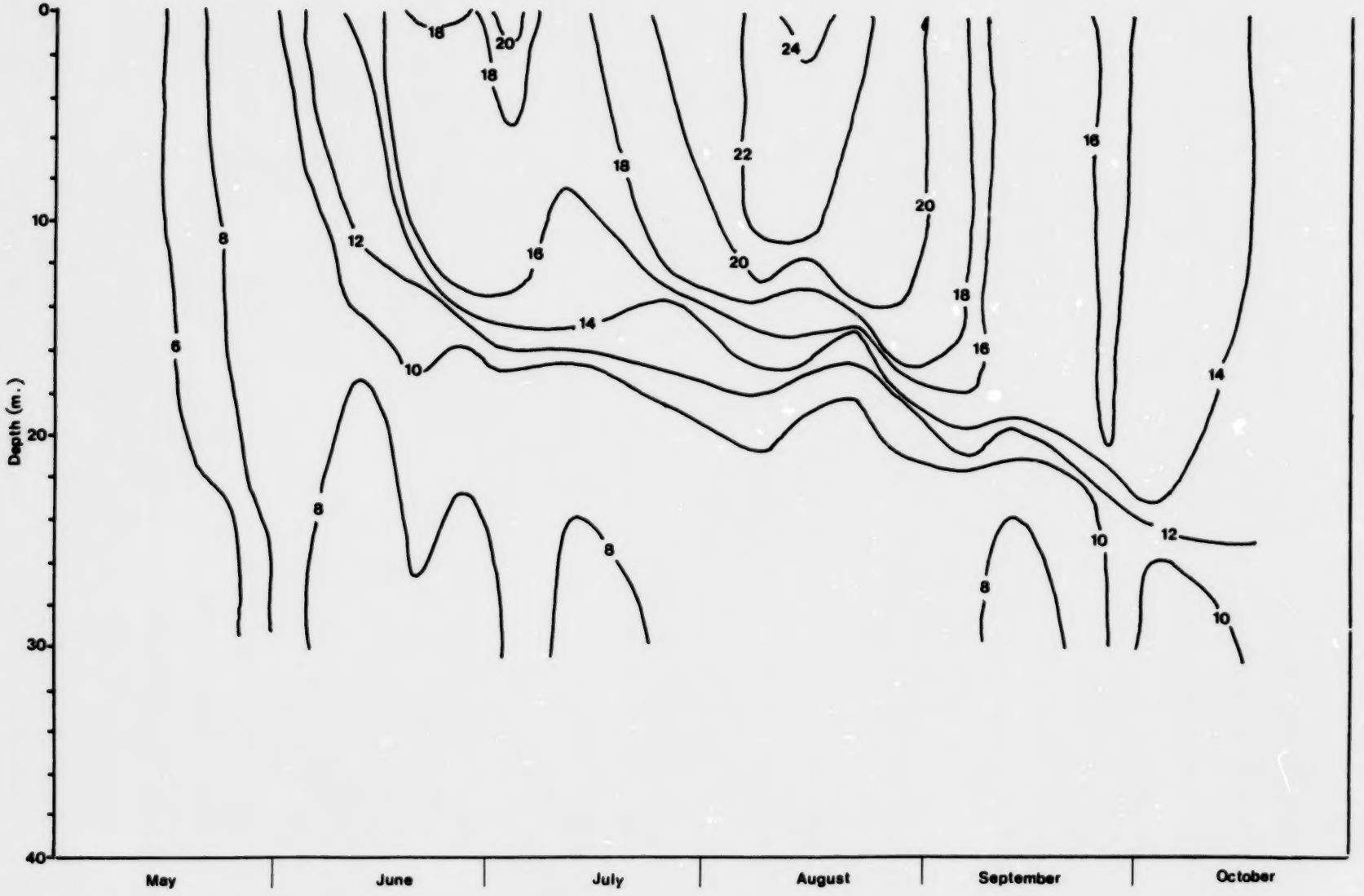
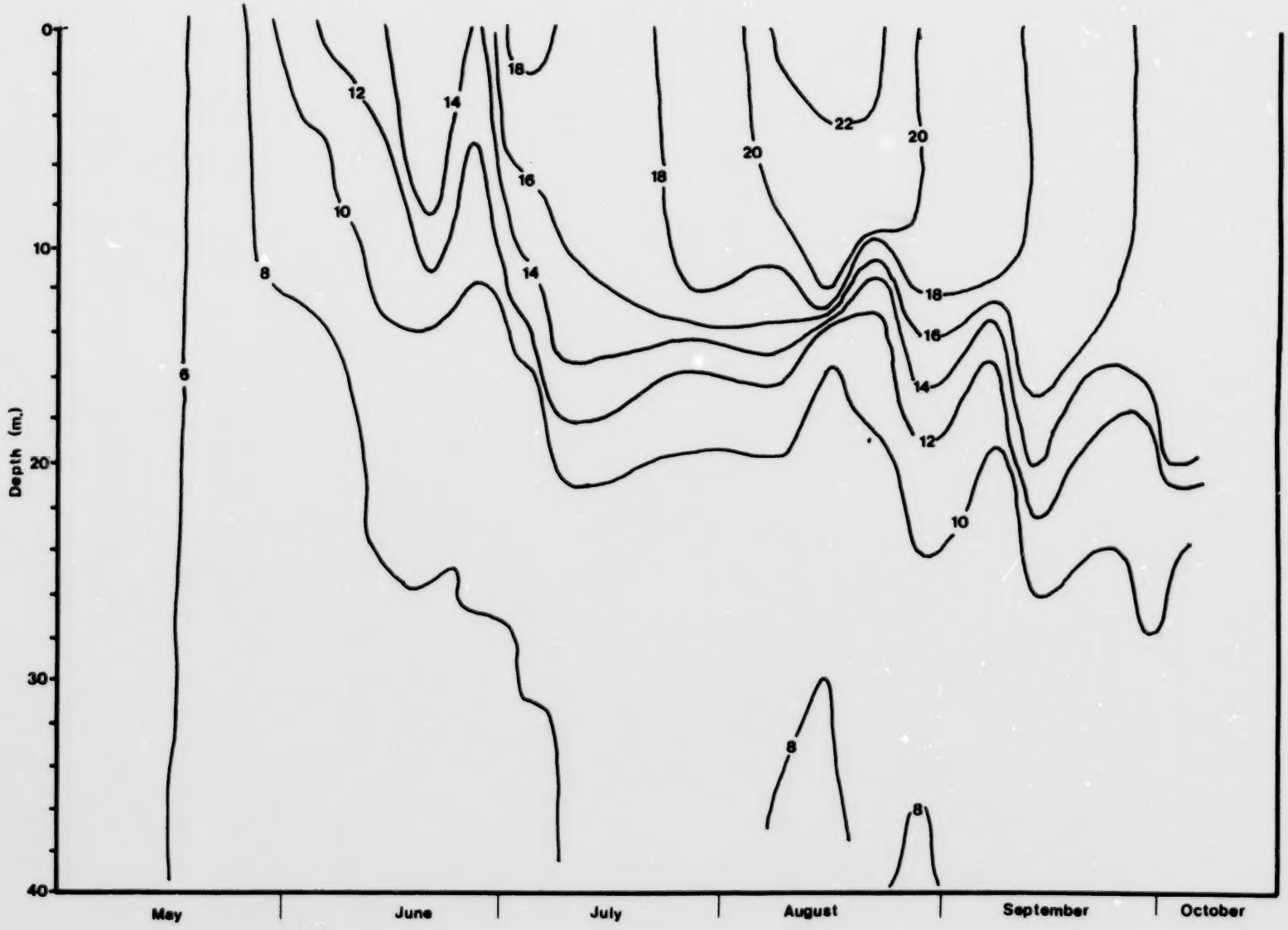


Figure 6: Depth-time isotherms (C) at K42, May to October 1984



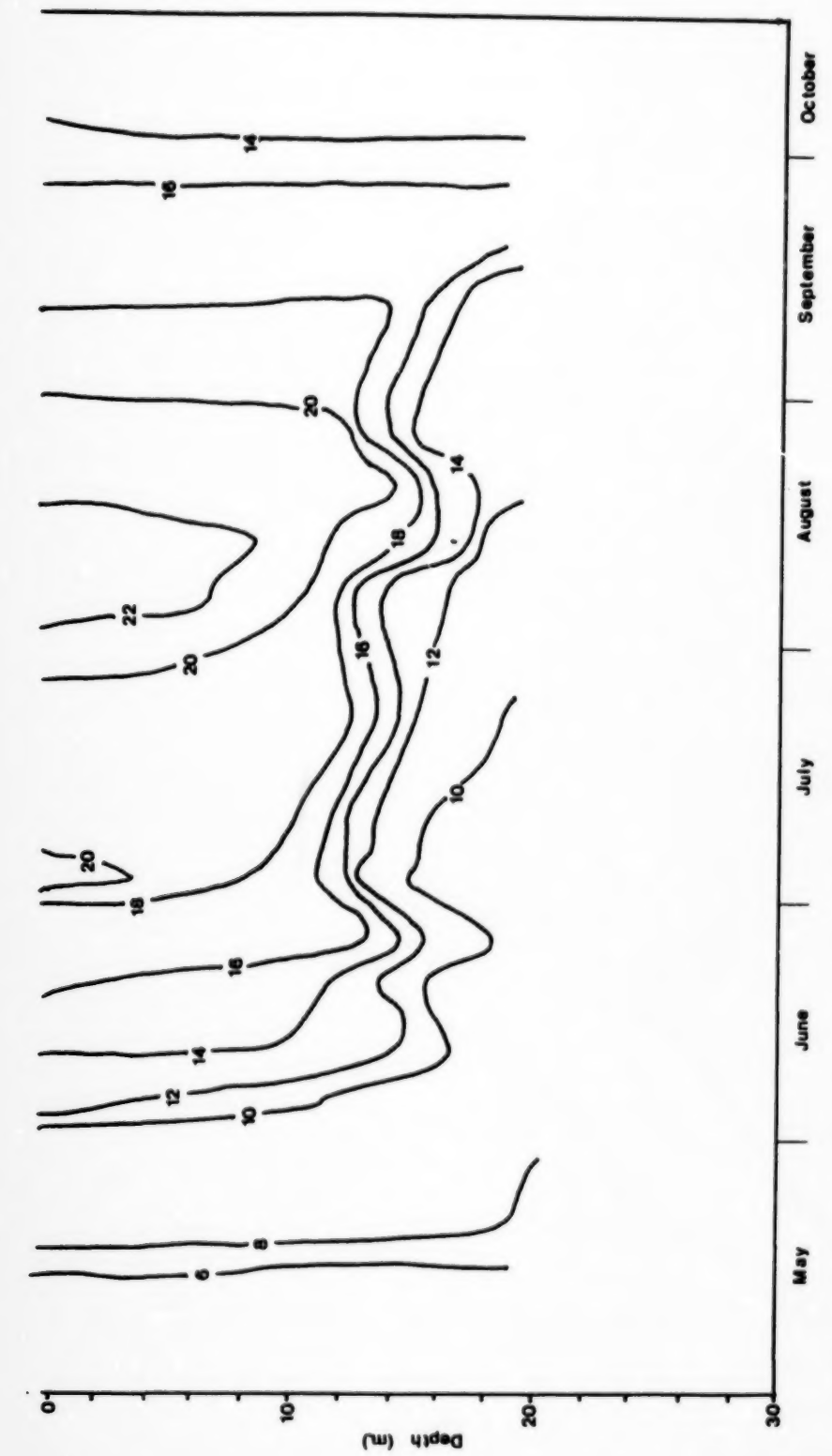


Figure 7: Depth-time isotherms (C) at S15, May to October 1984

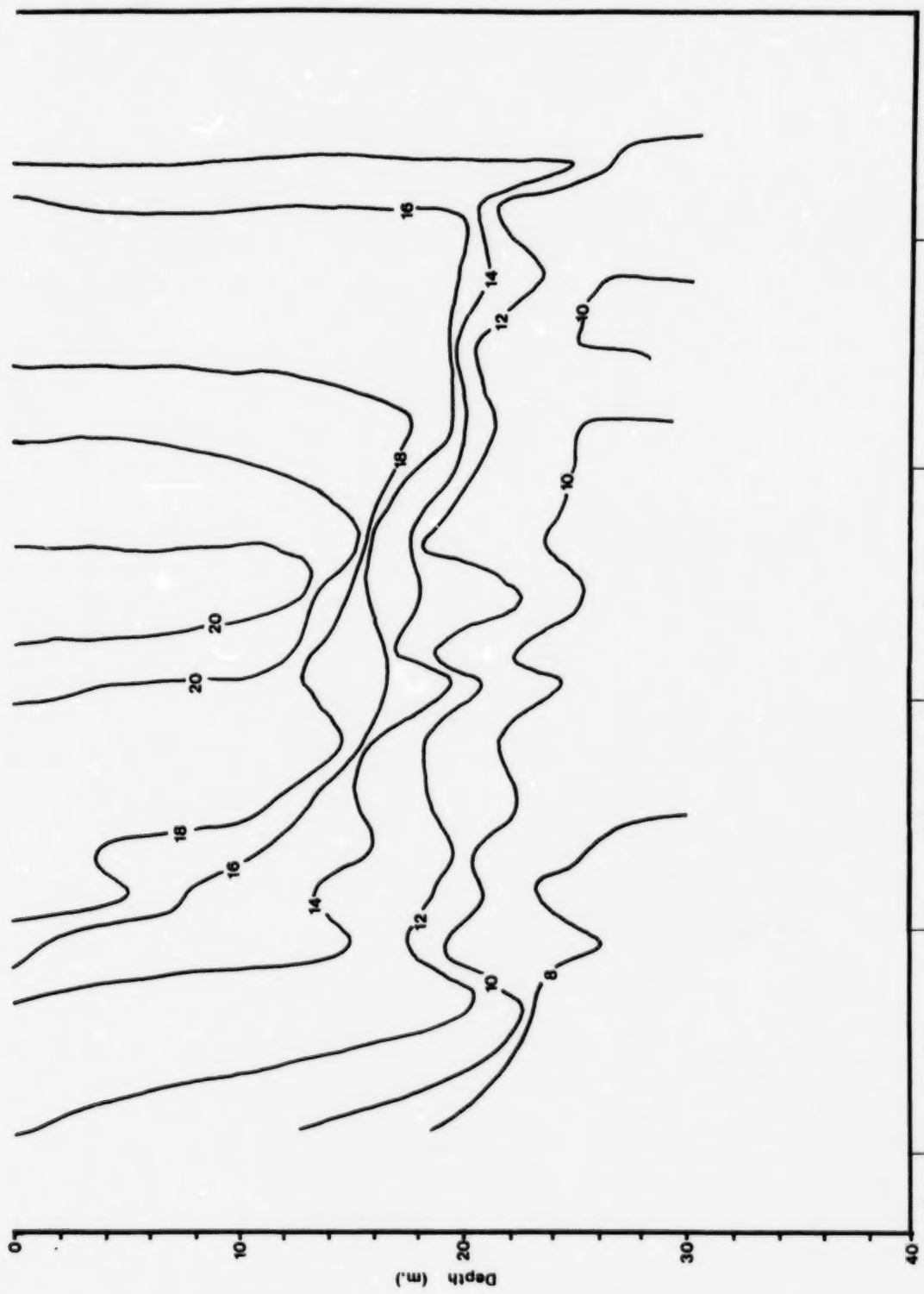


Figure 8: Depth-time isotherms (C) at K45, May to October 1985

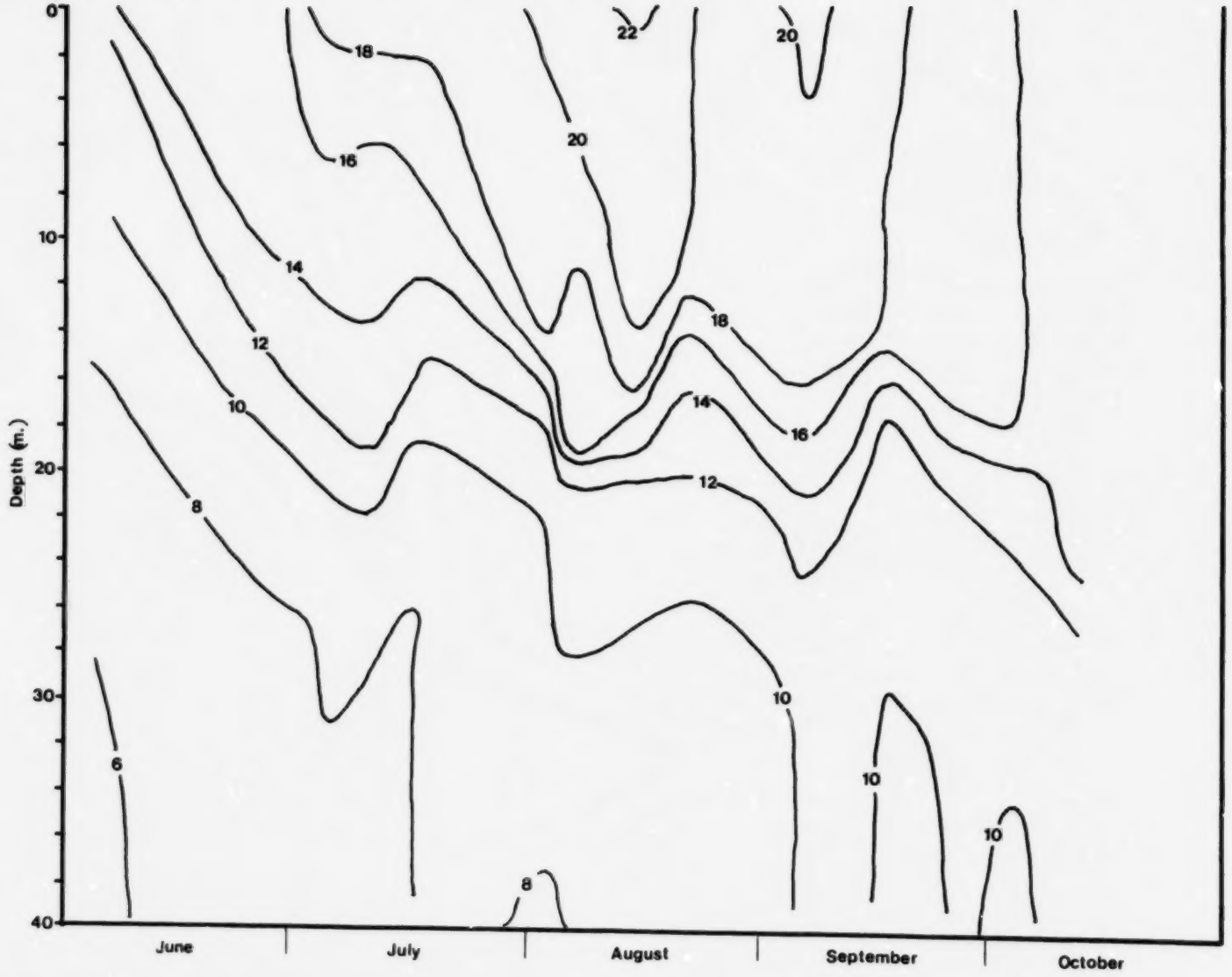


Figure 9: Depth-time isotherms (C) at K42, June to October 1985

Figure 10: Depth-time isotherms (C) at S15, May to October 1985

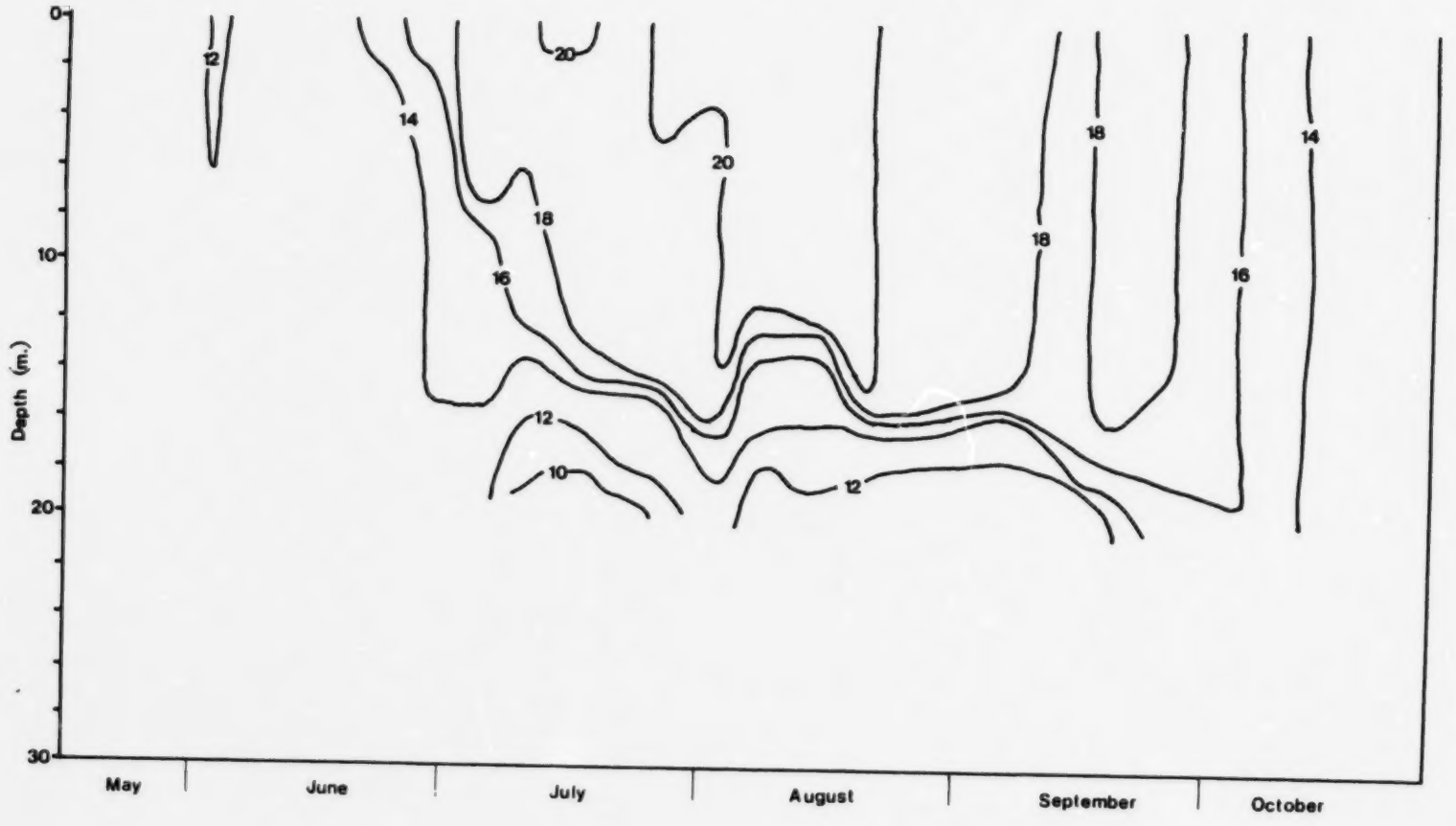


Figure 11: Depth-time isotherms (C) at K45, May to October 1986

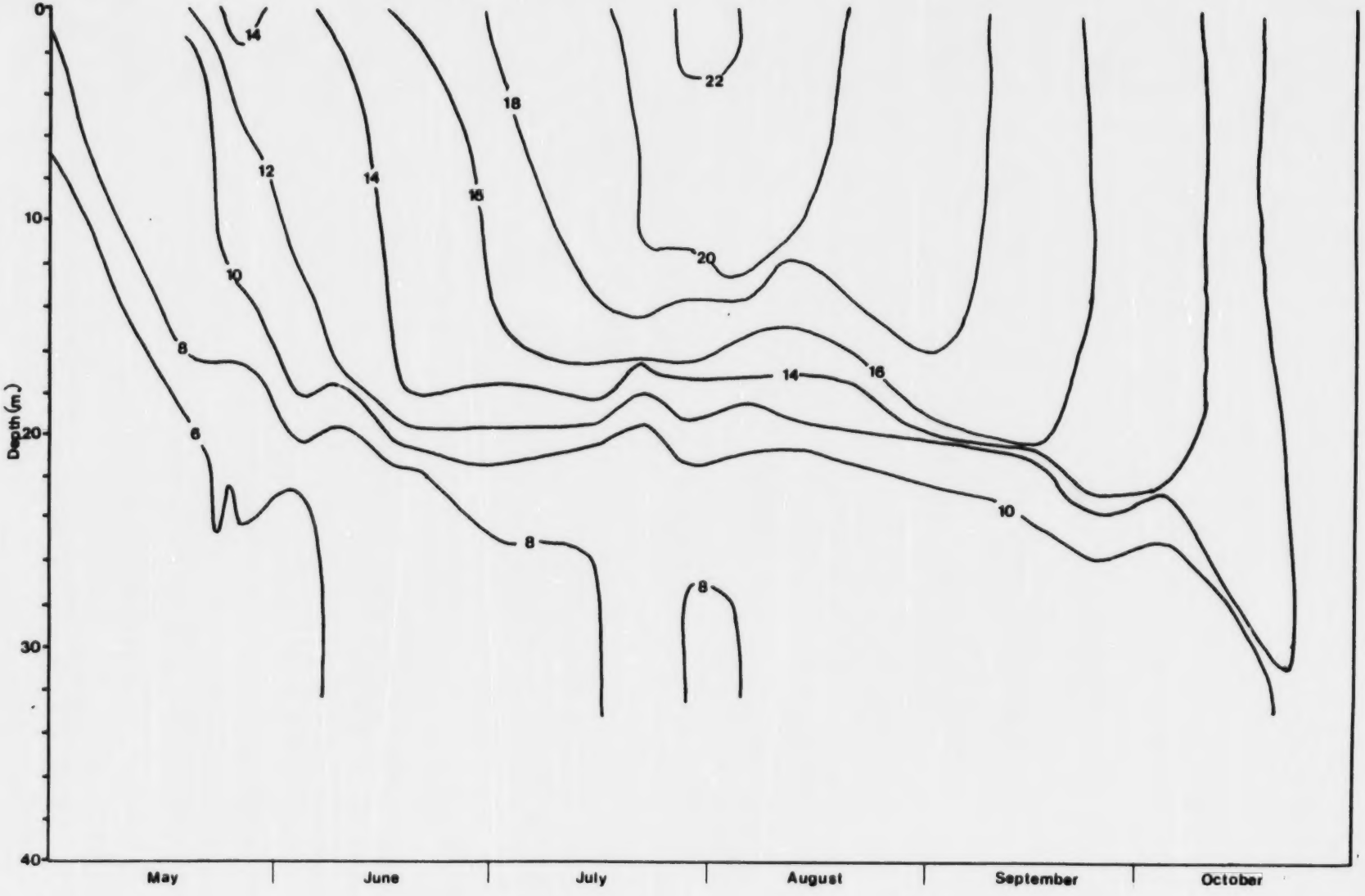
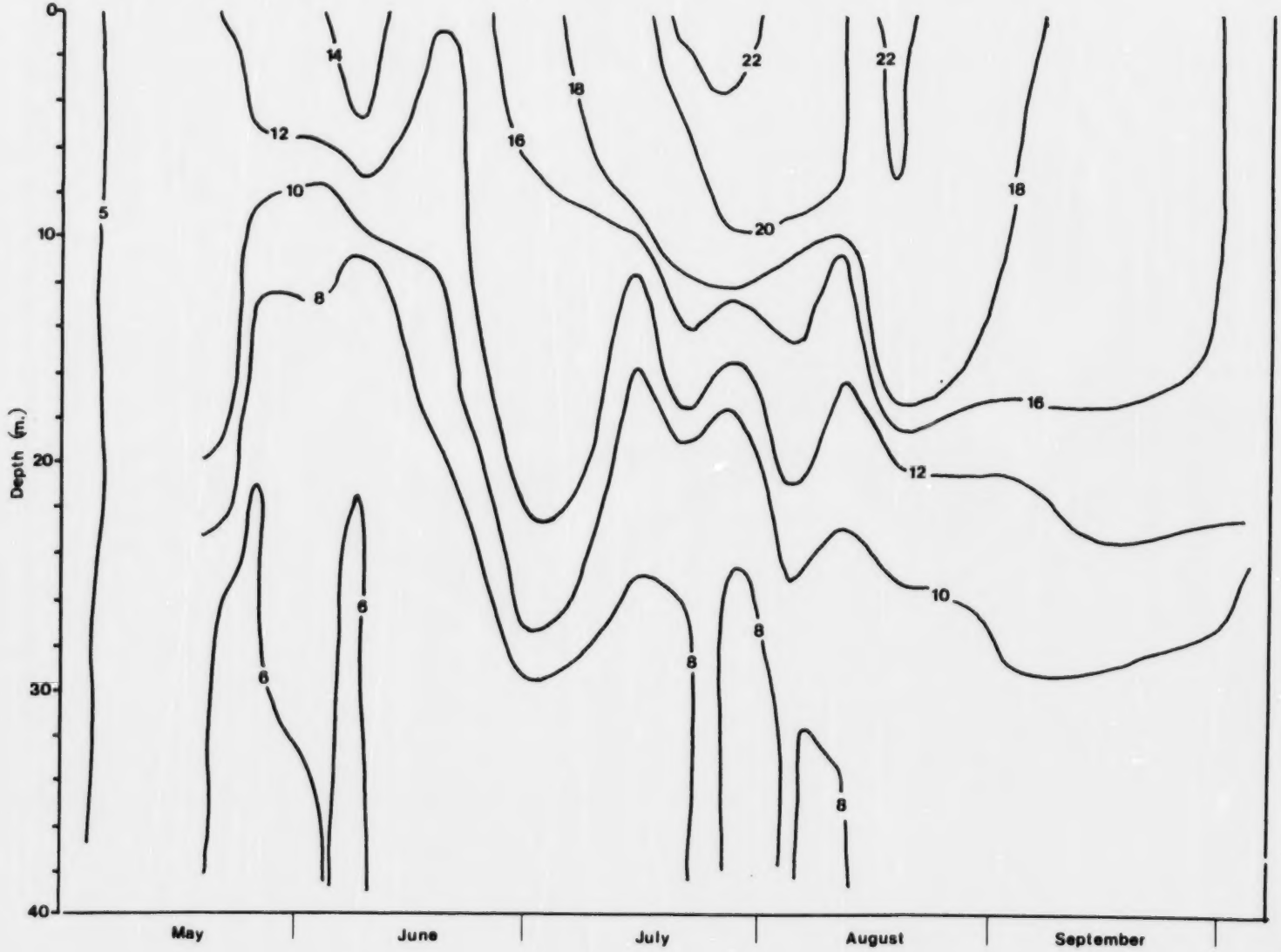


Figure 12: Depth-time isotherms (C) at K42, May to September 1986



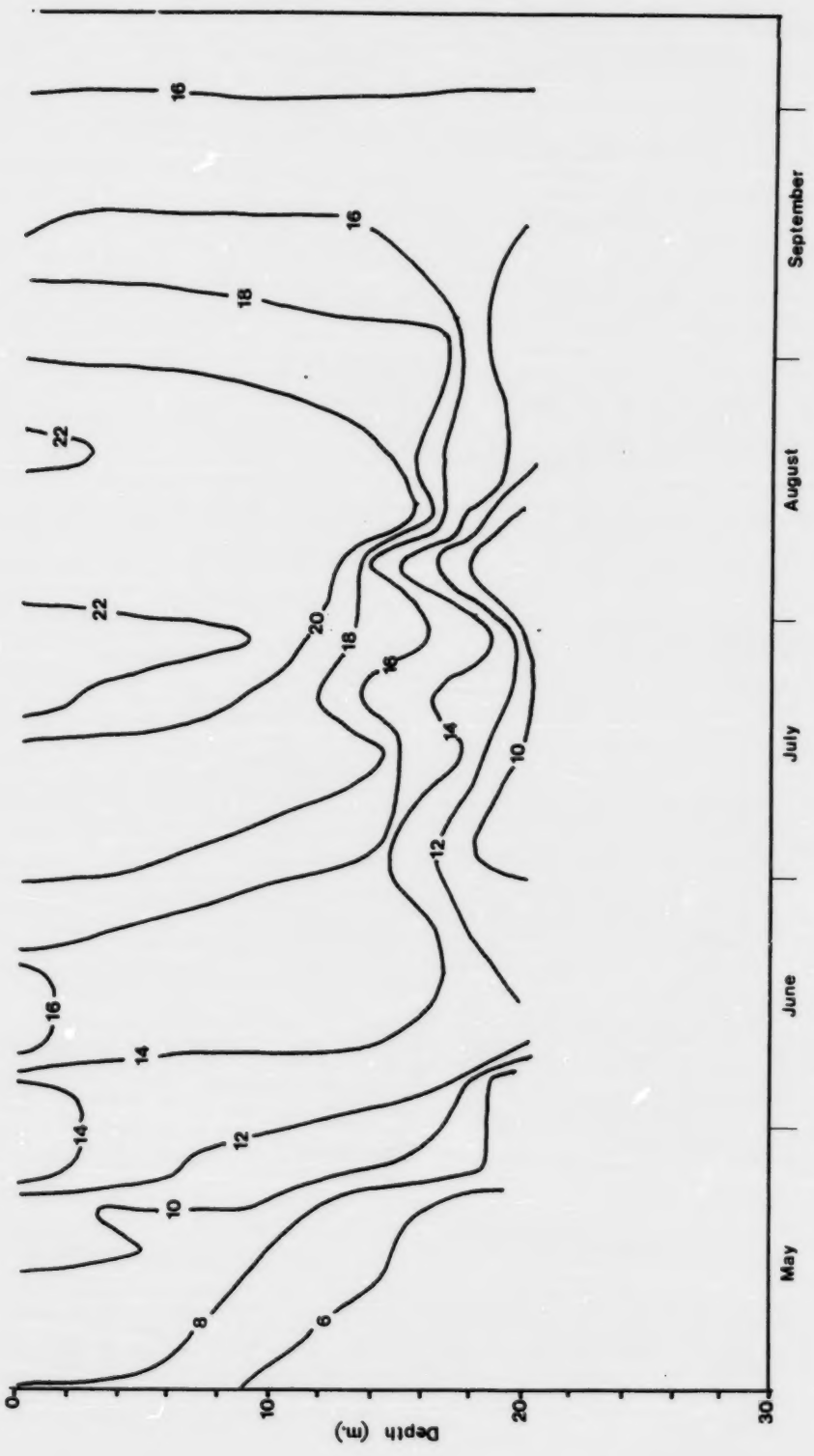


Figure 13: Depth-time isotherms (C) at S15, May to October, 1986

seen. (Figures 14-16). Mean hypolimnetic summer temperatures ranged from 7.86 - 8.99°C at K45 and K42, and from 11.7 - 13.65°C at S15 (Table 4). Mean hypolimnetic temperatures were statistically higher at S15 than at the other 2 sites each year. K45 and K42 were statistically equal, and for each site there were no statistical differences between years.

Table 4: Mean hypolimnetic temperature, calculated using values at 5m above bottom for K45 and K42, and at 3m above bottom for S15, from June 1 - fall turnover, 1984 - 1986. (n=number of observations)

Station	Mean hypolimnetic temperature (°C) + Standard Deviation			
	1984	1985	1986	Combined
K45	8.718 + 1.065 n = 17	8.987 + 1.494 n = 15	8.15 + 1.202 n = 12	8.655 + 1.232 n = 44
K42	8.369 + .8614 n = 16	8.823 + 1.392 n = 13	7.861 + 1.154 n = 13	8.352 + 1.108 n = 42
S15	11.7 + 3.202 n = 11	13.454 + 1.128 n = 11	13.65 + 1.948 n = 10	12.912 + 2.196 n = 32
Combined	9.336 + 1.751 n = 44	10.192 + 1.33 n = 39	9.614 + 1.394 n = 35	

Figure 14: Dissolved oxygen levels and temperature readings taken at 5m above bottom at K45 and K42, and 3m above bottom at S15, June 1 to fall turnover, 1984

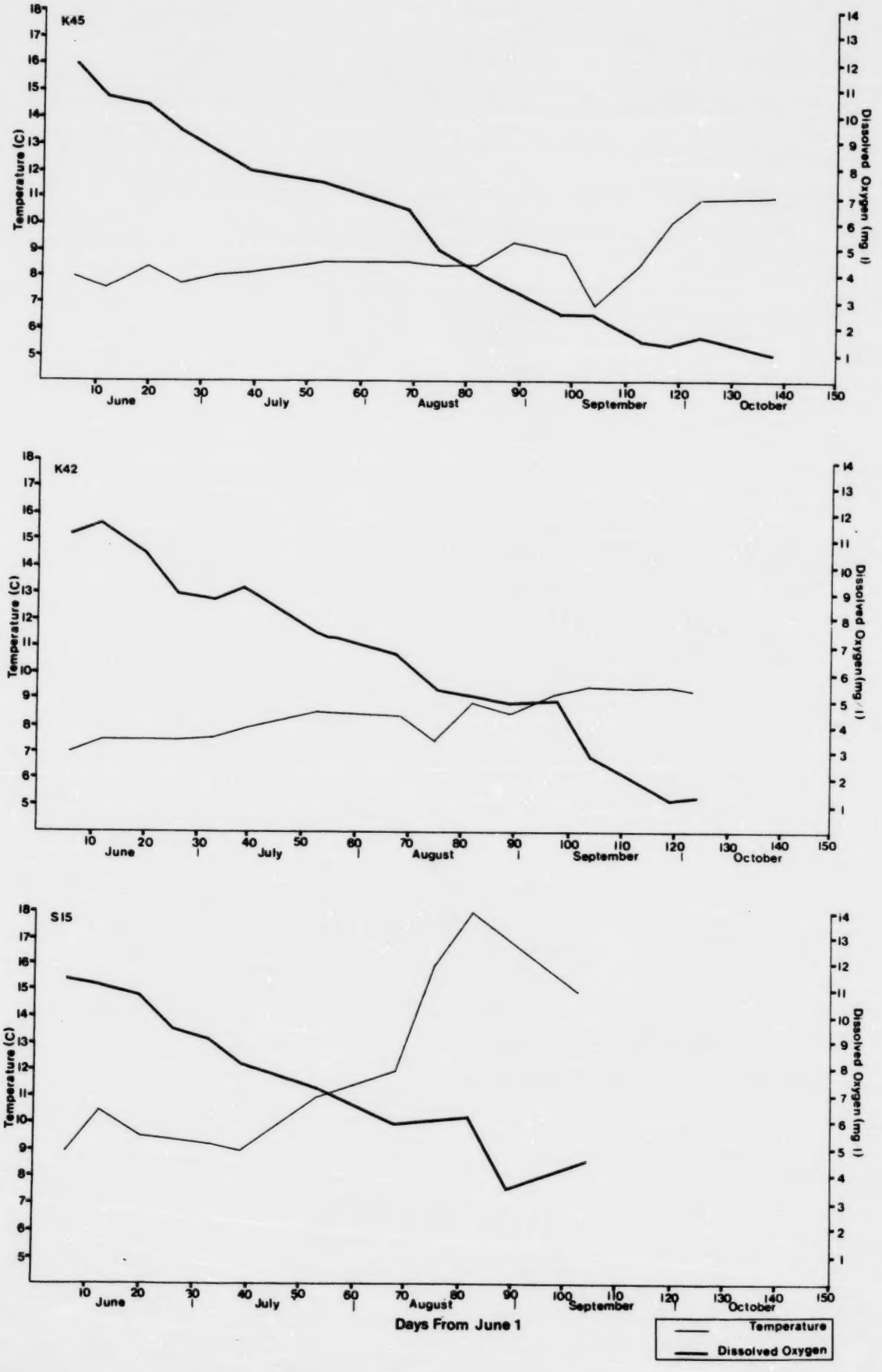


Figure 15: Dissolved oxygen levels and temperature readings, taken at 5m above bottom at K45 and K42, and 3m above bottom at S15, June 1 to fall turnover, 1985

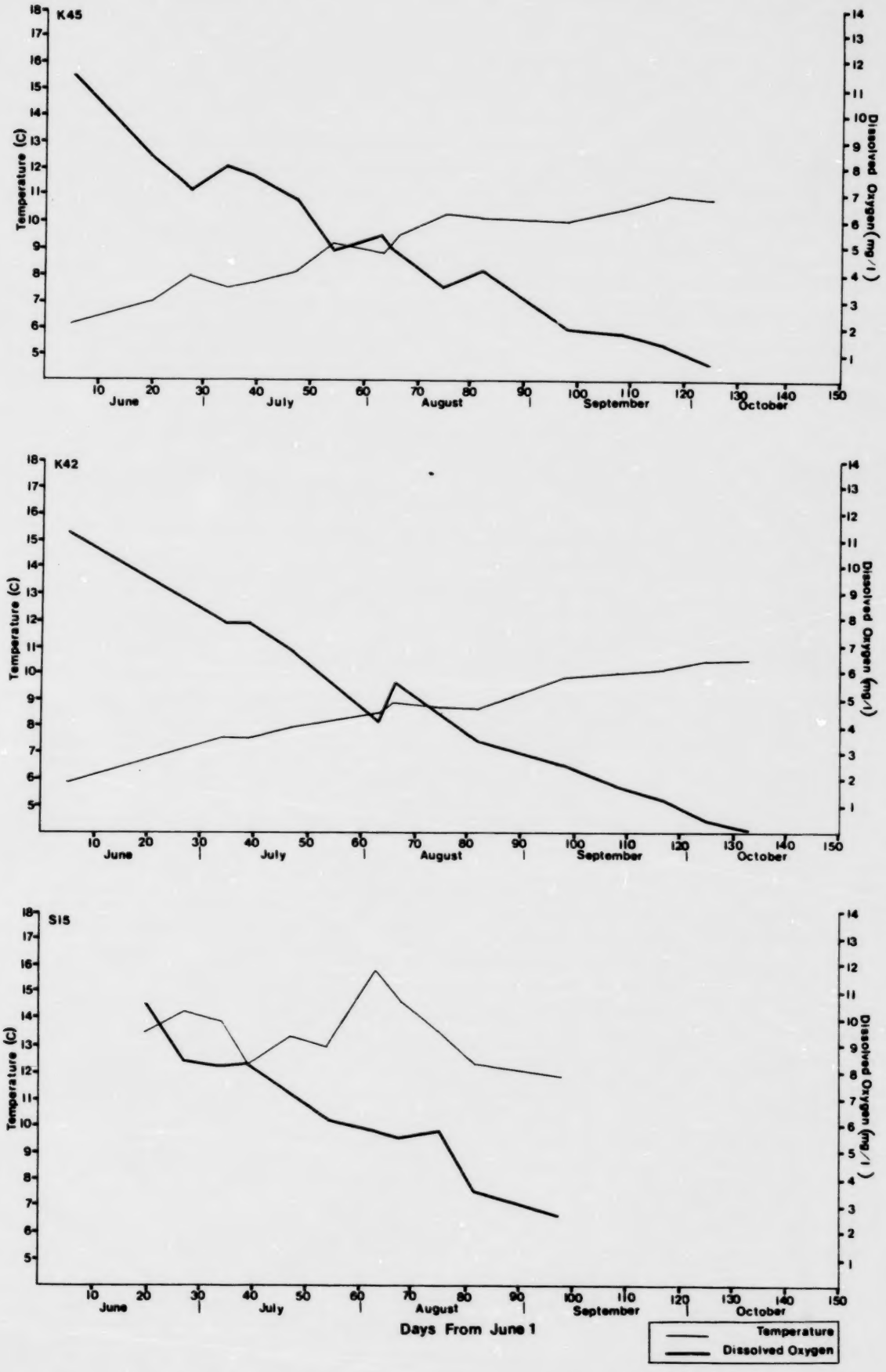
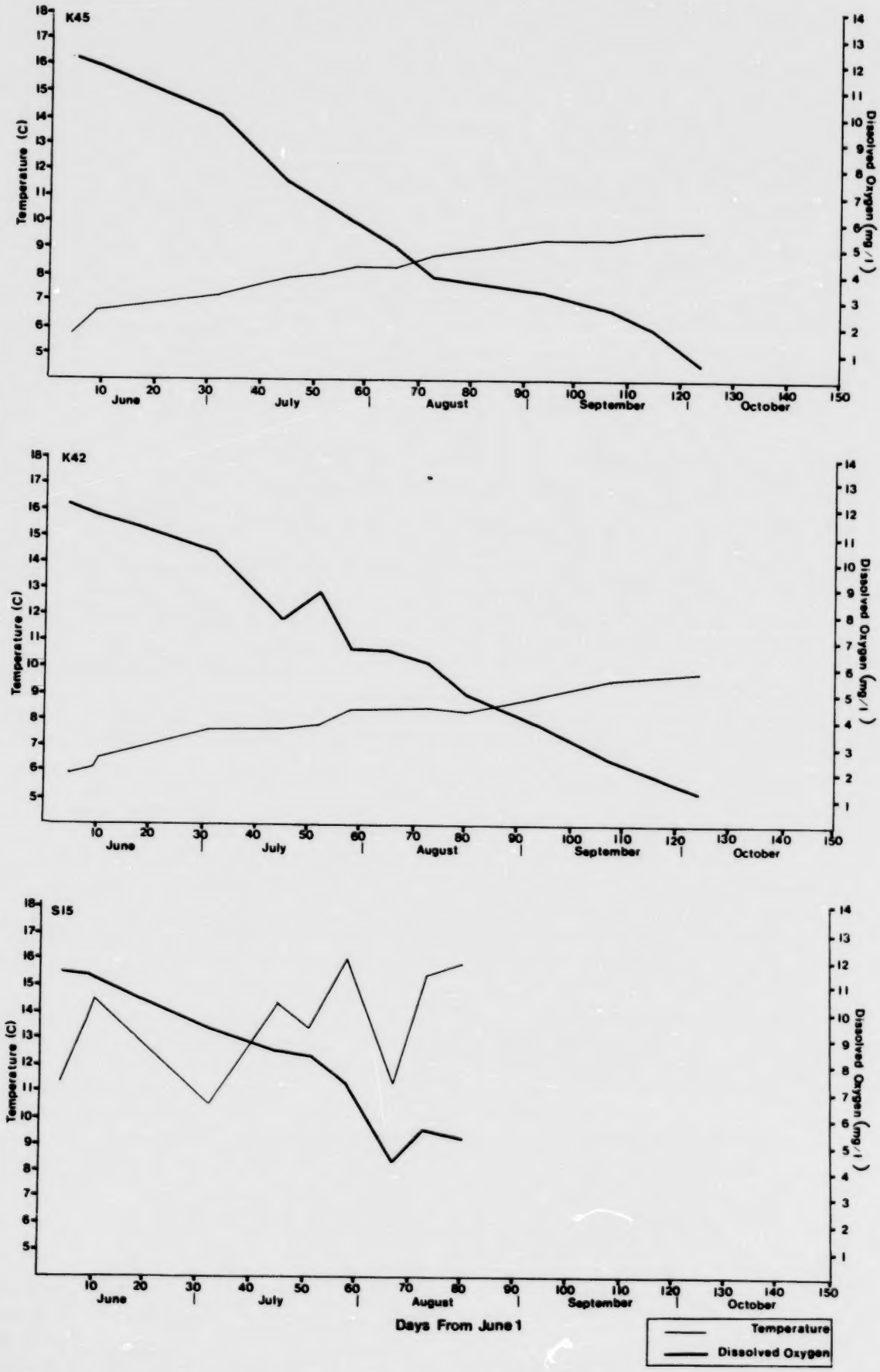


Figure 16: Dissolved oxygen levels and temperature readings, taken at 5m above bottom at K45 and K42, and at 3m above bottom at S15, June 1 to fall turnover, 1986



3.3 Dissolved oxygen

Depth-time isopleths are given for the 3 sites for each of the three sampling years (Figures 17-25), showing the seasonal trends in dissolved oxygen levels.

Levels of approximately 12 mg/l persisted from late May to early June, with inverse stratification usually occurring in mid to late June. Surface dissolved oxygen levels decreased slightly over the summer, from 12-13 mg/l to approximately 8 mg/l in August or September, rising again to 9 mg/l in October 1984, and approximately 12 mg/l in late October, 1986. The greatest changes were seen in the hypolimnion, where values fell from 11-12 mg/l at the seasons' start, to less than 1 mg/l in October. The 4 mg/l isopleth usually appeared in mid-August. At K45, dissolved oxygen levels were less than 2.5 mg/l throughout the entire hypolimnion in mid-September, and less than 1 mg/l by early October. K42 hypolimnion values were also very low, with values less than 3 mg/l in late September 1984, and in mid September less than 2 mg/l in 1985, and 3 mg/l in 1986. By early October values less than 1-2 mg/l persisted in the hypolimnion. At S15 however, hypolimnion values ranged from 2-4 mg/l in 1984 and 1985, and from 2-6 mg/l in 1986, from late August to fall turnover.

Temperature and dissolved oxygen values in near bottom waters were inversely related at all sites each year, with maximum temperatures approximately coinciding with minimum dissolved oxygen levels in September (Figures 14-16).

Figure 17: Depth-time isopleths of dissolved oxygen concentrations (mg/1) at K45, May to October 1984

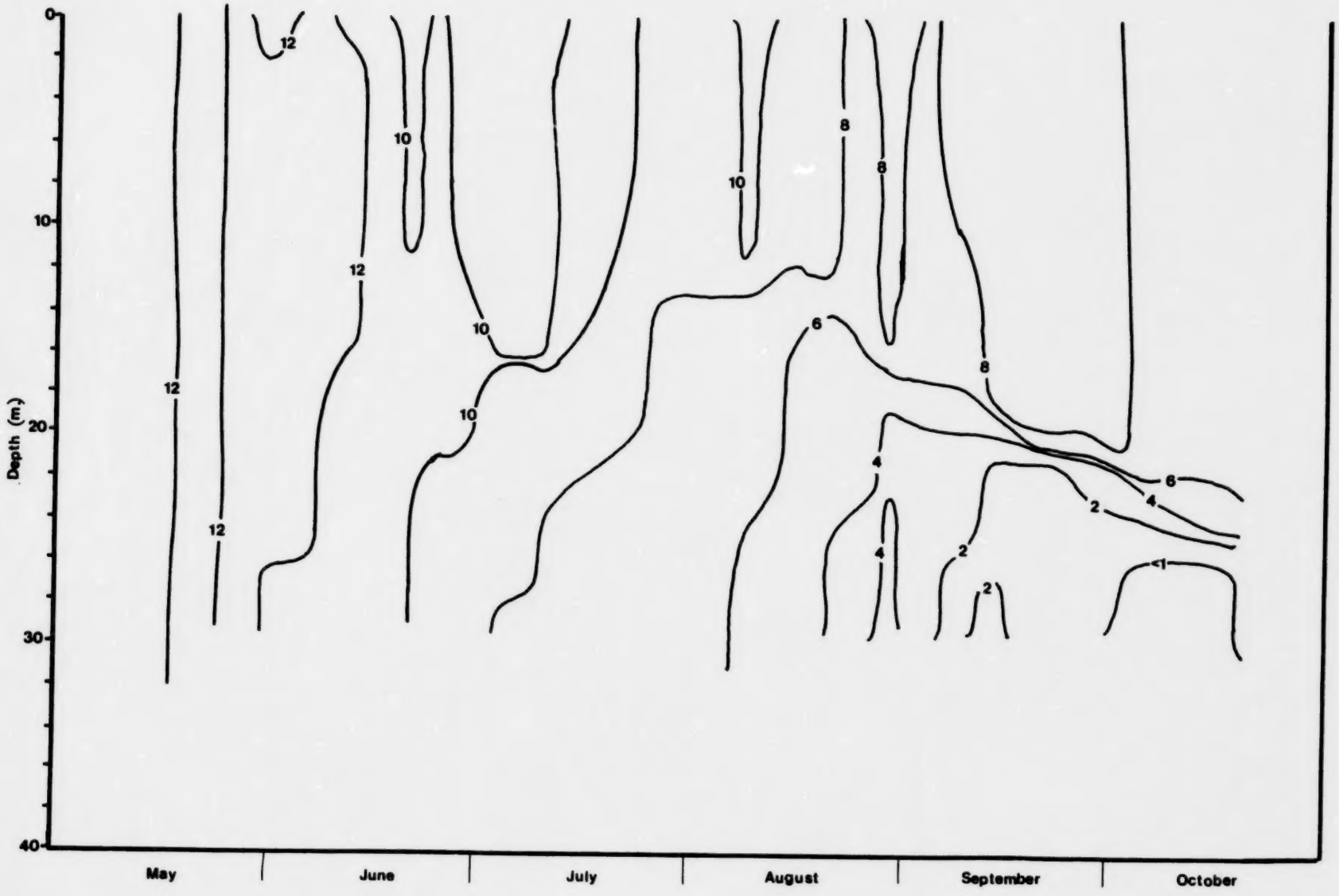


Figure 18: Depth-time isopleths of dissolved oxygen concentrations (mg/1) at K42, May to October 1984

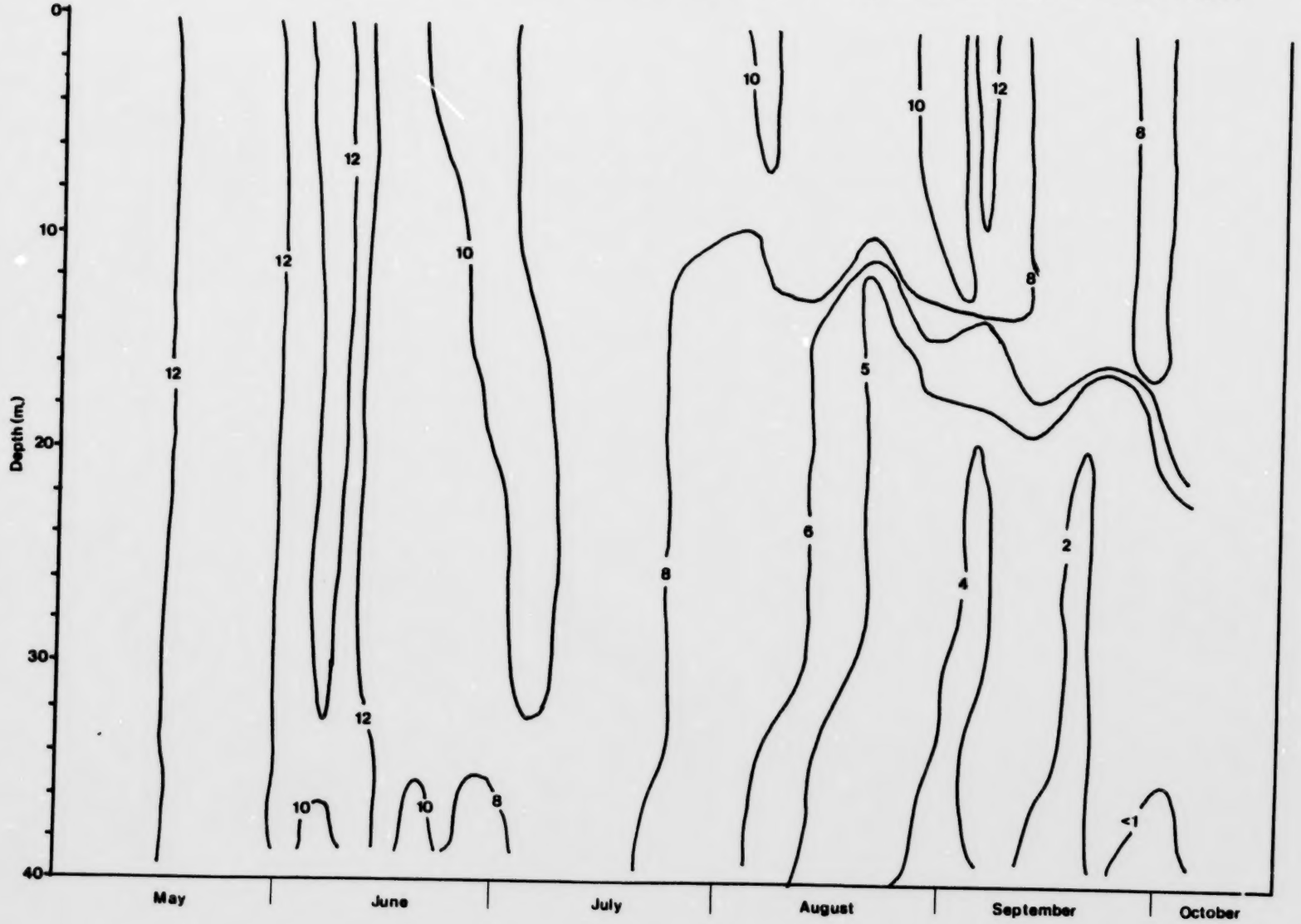
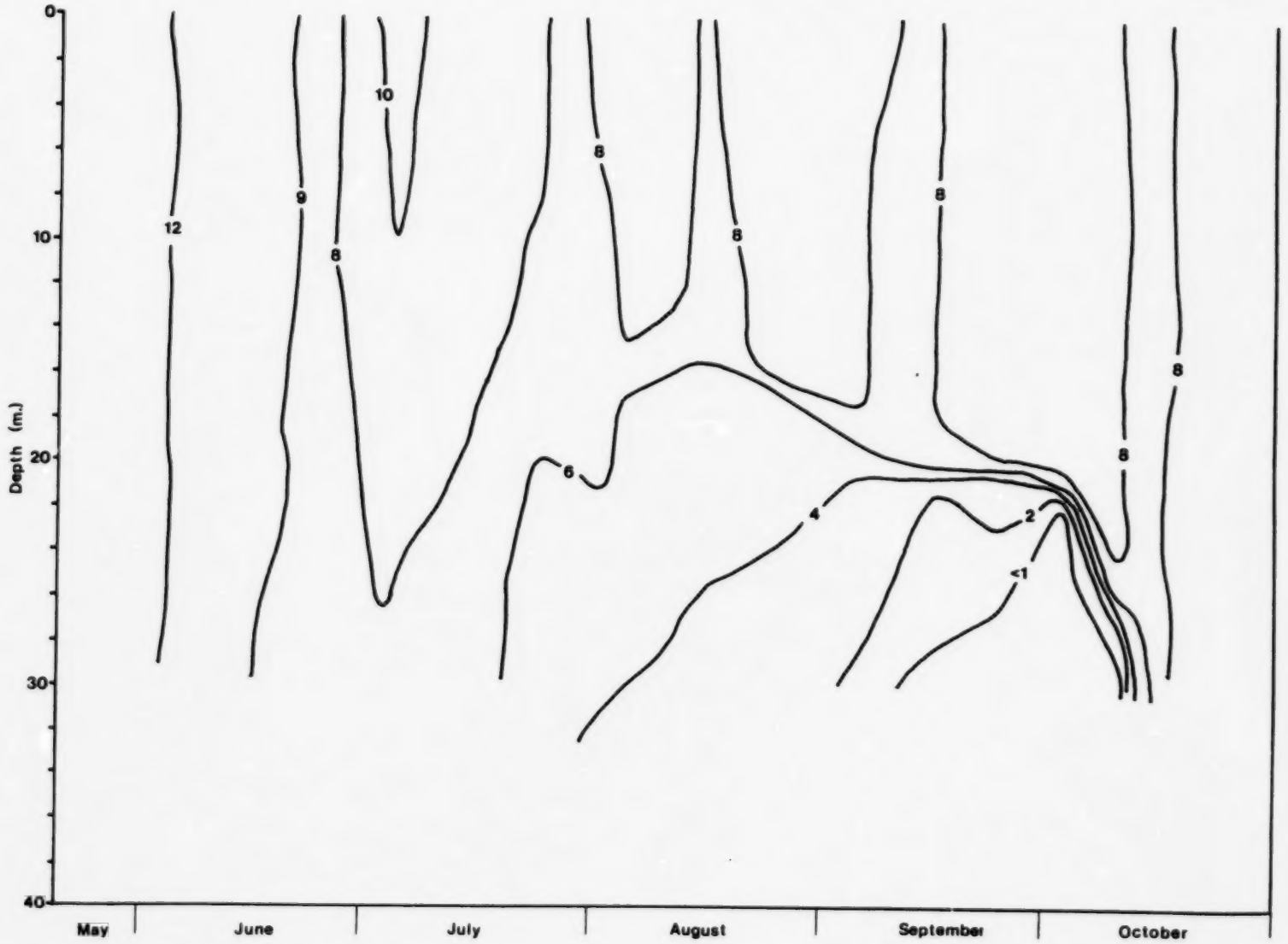


Figure 19: Depth-time isopleths of dissolved oxygen concentrations (mg/l) at S15, May to October 1984

Figure 20: Depth-time isopleths of dissolved oxygen concentrations (mg/1) at K45, May to October 1985



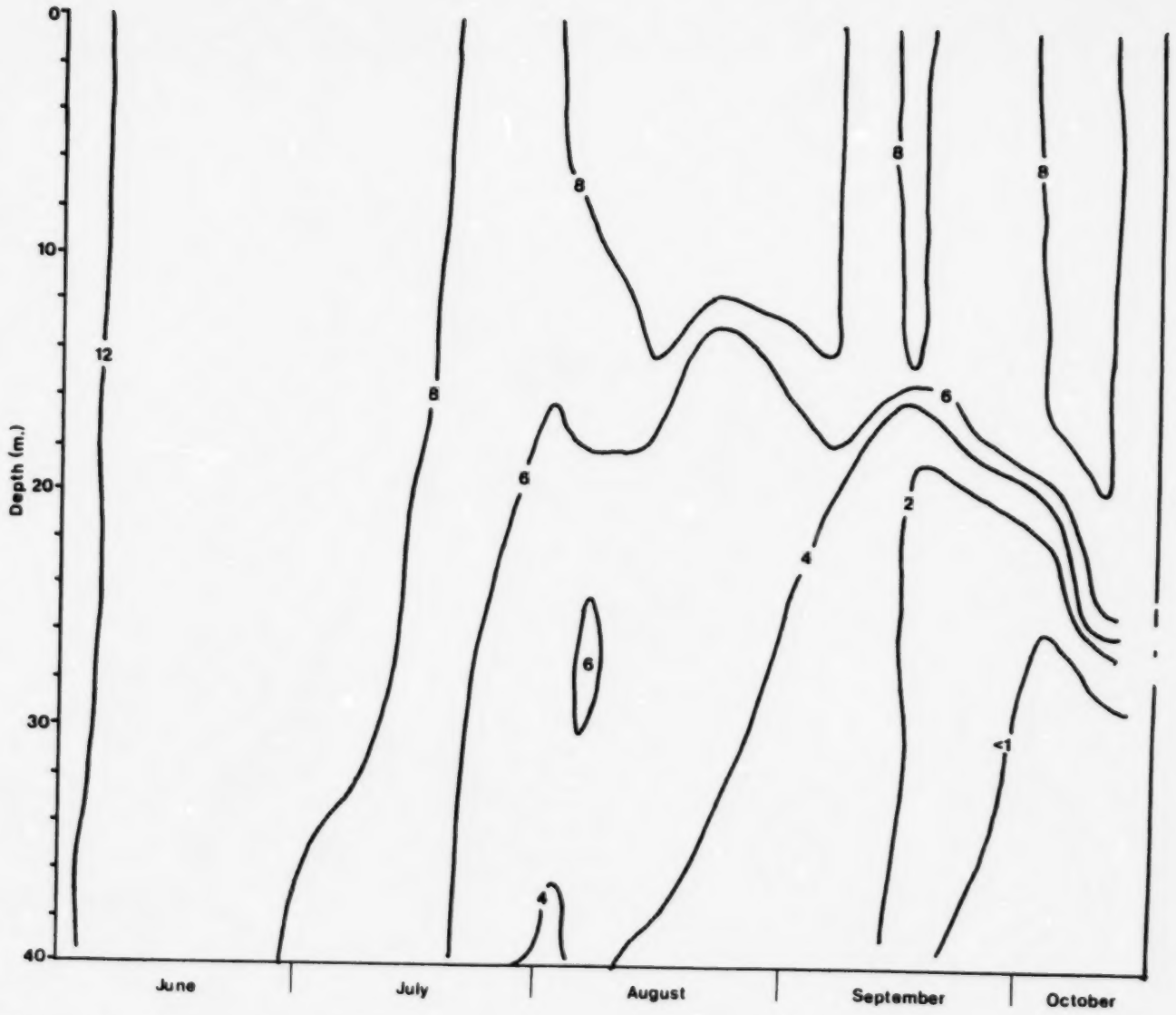


Figure 21: Depth-time isopleths of dissolved oxygen concentrations (mg/l) at K42, June to October 1985

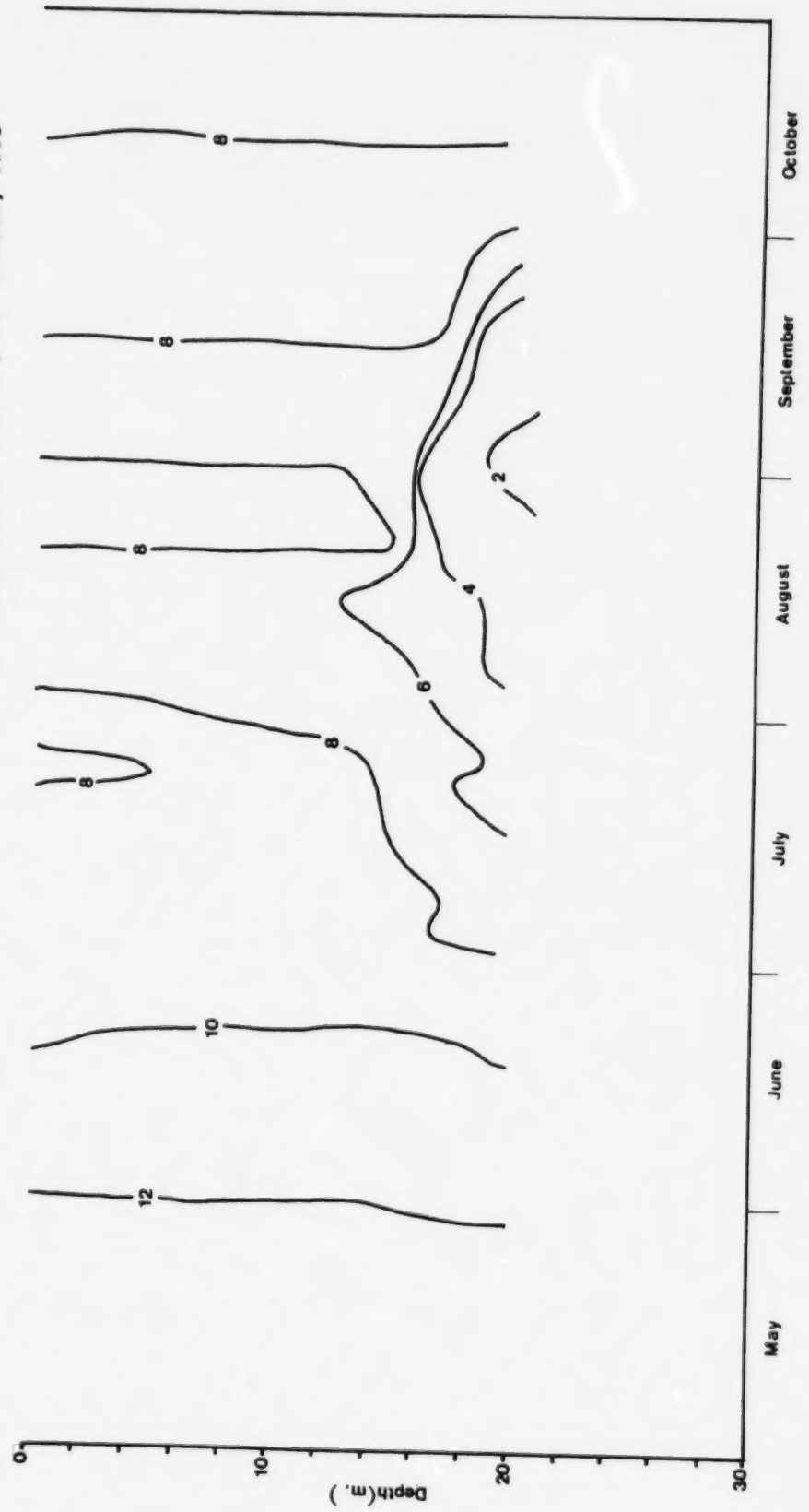


Figure 22: Depth-time isopleths of dissolved oxygen concentrations (mg/l) at S15, May to October, 1985

Figure 23: Depth-time isopleths of dissolved oxygen concentrations (mg/1) at K45, May to October 1986

Figure 24: Depth-time isopleths of dissolved oxygen concentrations (mg/l) at K42, May to October 1986

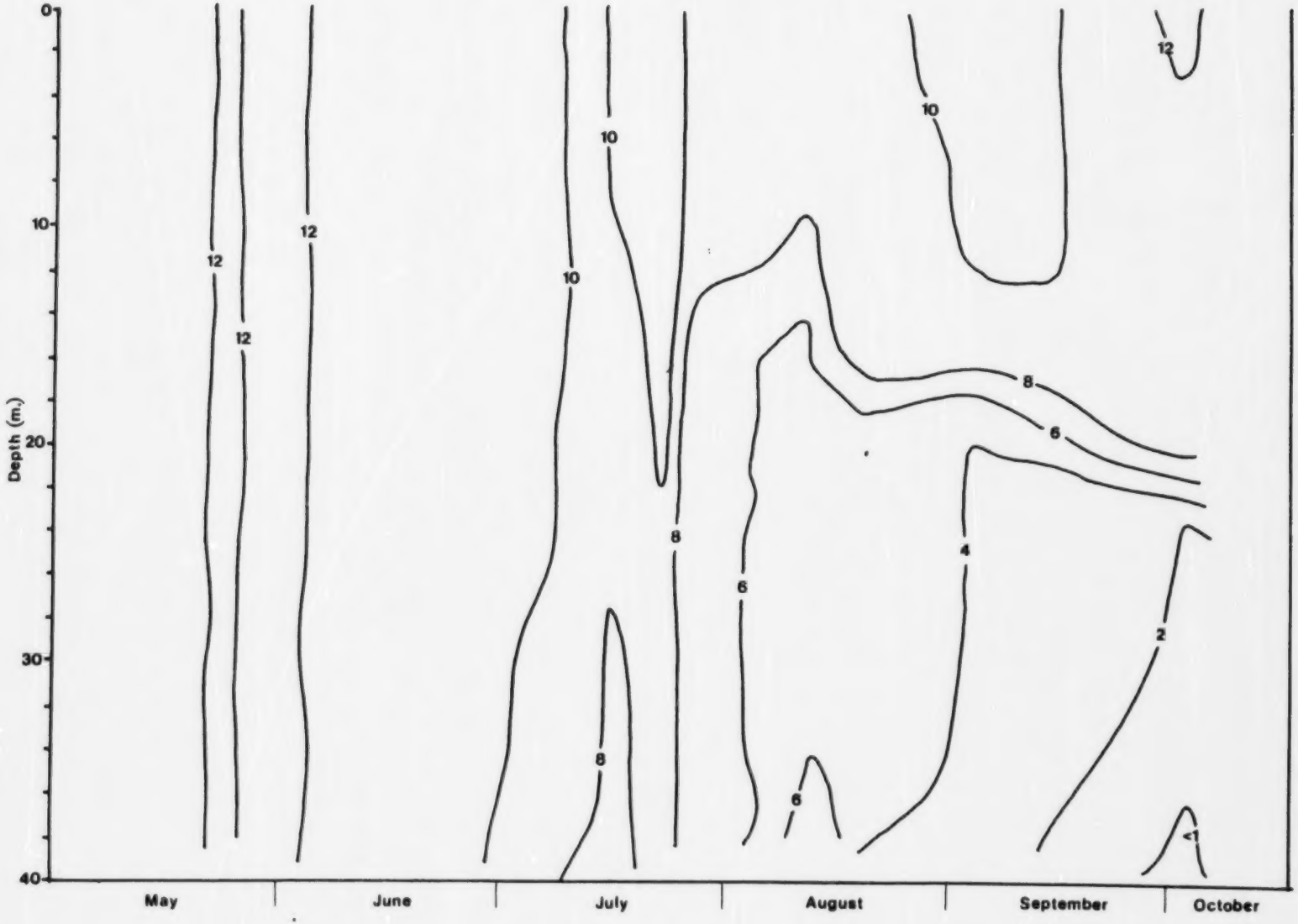
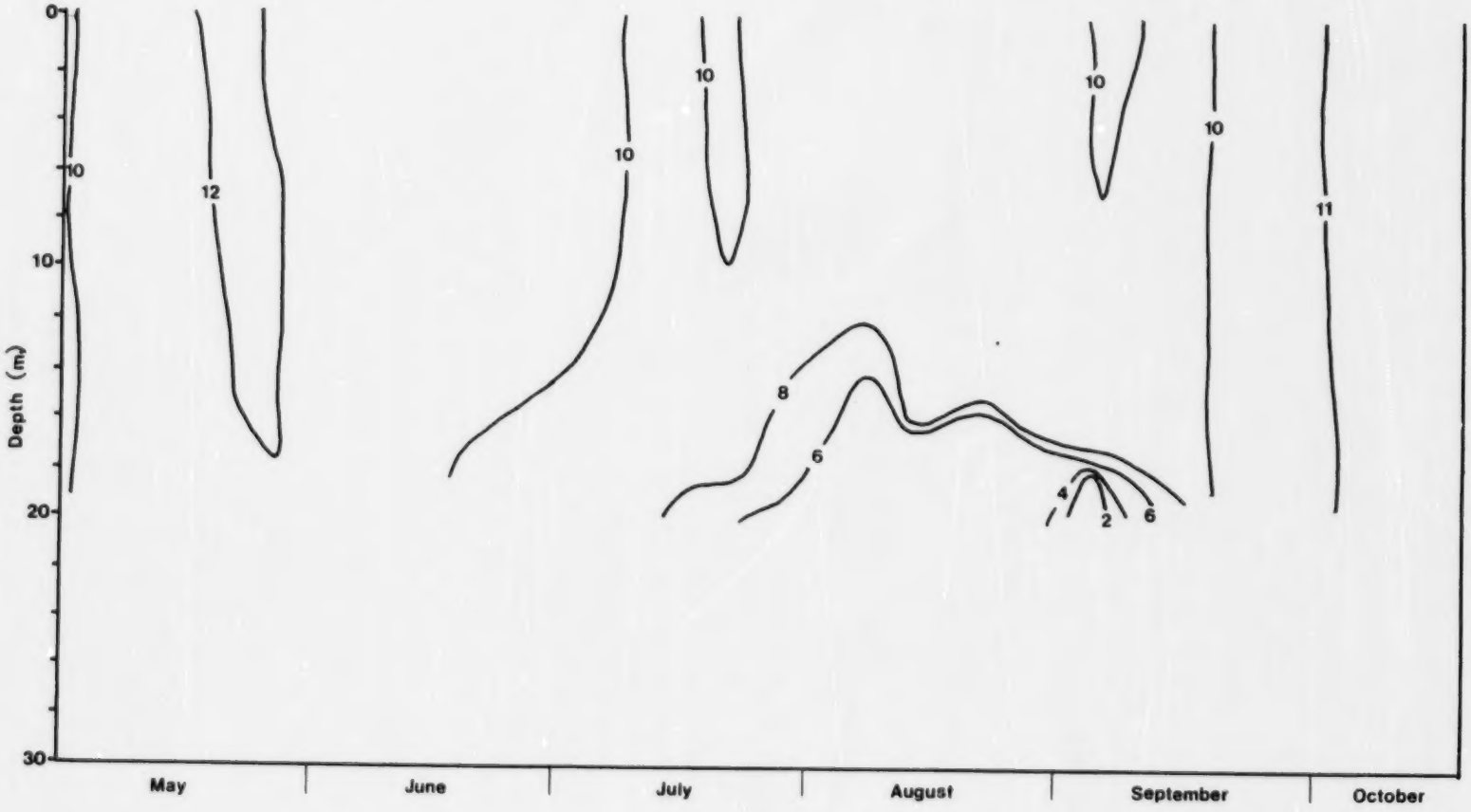


Figure 25: Depth-time isopleths of dissolved oxygen concentrations (mg/1) at S15, May to October 1986



The dissolved oxygen depletion rates ranged from -.07866 to -0.09755 mg/l/day. No statistically significant differences were found between sites or years (Table 5).

Table 5: Dissolved oxygen depletion rates (mg/l/day) calculated using values at 5m above bottom for K45 and K42, and 3m above bottom for S15, from June 1 to fall turnover, 1984-1986 (n = number of observations)

Year	Station	n	Dissolved oxygen depletion rate mg/l/day	Oxygen depletion equation y=oxygen concentration (mg/l) x=days from June 1
1984	K45	15	-.08789	y=11.874 -.08789x
	K42	15	-.08689	y=12.168 -.08689x
	S15	12	-.07868	y=11.797 -.07868x
1985	K45	15	-.08319	y=10.544 -.08319x
	K42	13	-.08425	y=10.921 -.08425x
	S15	11	-.09068	y=11.554 -.09068x
1986	K45	12	-.09755	y=12.533 -.09755x
	K42	13	-.09447	y=12.822 -.09447x
	S15	10	-.09096	y=12.204 -.09096x

4.0 DISCUSSION

4.1 Secchi Disc Readings

Similar to the findings of this study, Willox (1982) reported a decrease in secchi depths that occurred in late summer at all three sites; his graphs also show a slight rise in values in mid-September to mid-October.

Except Willox (1982), who reported a mean secchi disc depth of 6.44m, average secchi depths reported from 1970 to 1983 range from 3 - 5.5m (Ralston et al, 1975; DesJardine, 1980; Dobson et al, 1982; Waring, 1986).

4.2 Temperature and Dissolved Oxygen

Willox (1982), reported a relationship between dissolved oxygen depletion rates and mean hypolimnetic temperatures. This holds true for the results of this study when comparing years for any one site in that no statistical differences exist between either depletion rates or mean hypolimnetic temperatures. When comparing sites, however, although no statistical differences exist between depletion rates, mean hypolimnetic temperatures are higher at S15 than at K45 and K42. The mean hypolimnetic temperatures are statistically equal at K45 and K42 each year.

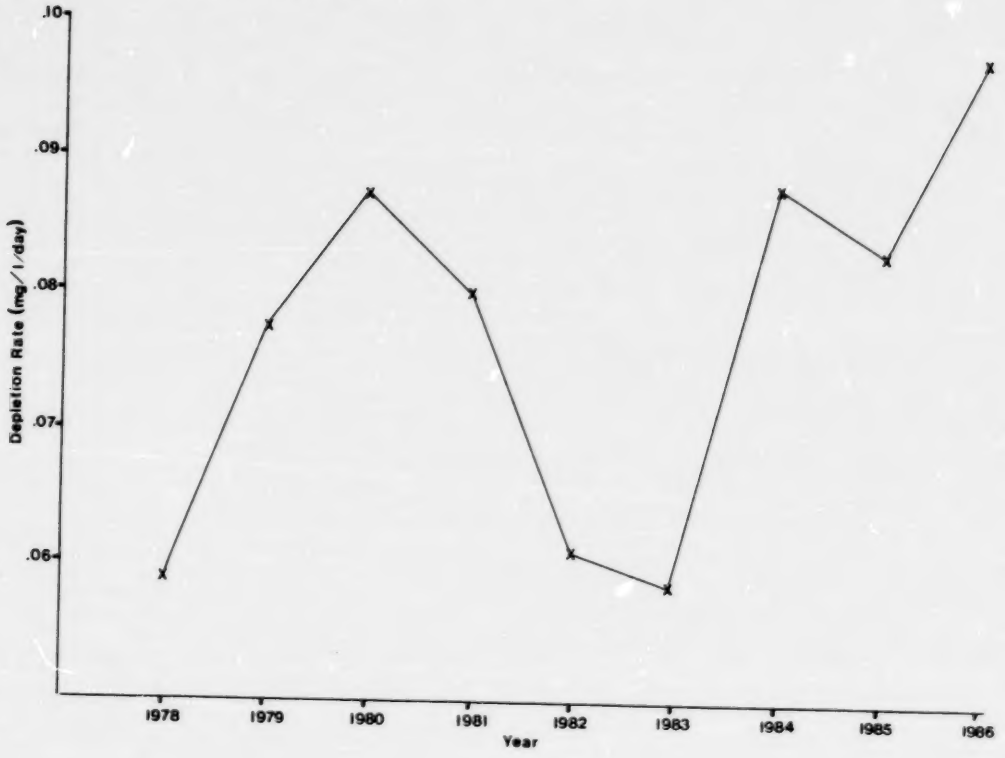
Although one would expect the depletion rates to be significantly higher at S15, because of the higher hypolimnetic temperatures, other factors are involved. The warming of the near bottom waters occurs much earlier at S15 than at either K45 or K42. Although the turnover of the lake occurs sometime in mid-October, the deepening of the epilimnion and metalimnion towards late summer affects the hypoli-

mnetic temperatures at the shallower S15 as early as mid-August. This results in a higher mean hypolimnetic temperature. Perhaps the use of values closer to the bottom than 3 metres above would more effectively discount this early warming of shallower waters, and better reflect the trends of near bottom waters.

In a multi-year comparison of dissolved oxygen depletion rates at K45, from 1978 to 1986 (DesJardine and Lawrence, 1978; DesJardine, 1980; Willox, 1982; Waring, 1986) the single statistical difference found was that the 1986 rate was statistically higher than the 1978, 1982 and 1983 rates. In comparing K45 mean hypolimnetic temperatures from 1978 to 1986 (DesJardine and Lawrence, 1978; DesJardine, 1980; Willox, 1982; Waring, 1986) the only statistical difference was that the 1981 mean temperature was higher than that in 1982. Although dissolved oxygen depletion is certainly affected by temperature, the changes in dissolved oxygen depletion rates do not concur with changes in mean hypolimmnetic temperatures in this 9 year comparison at K45 (Table 6). Depletion rates are plotted against year in Figure 16.

Perhaps of more relevance than the mean hypolimnetic temperature is the pattern of temperature changes in the hypolimnion: rate of temperature increase, timing of temperature fluctuations, and date of lake turnover. A statistical comparison of rate of hypolimnetic temperature increase and visual examination of temperature trends might provide more insight into the relationship between dissolved oxygen and temperature than the use of mean values.

Figure 26: Dissolved oxygen deplethion rates (mg/l/day) from 1978 to 1986 at K45



Even though there were no statistically significant differences in the dissolved oxygen depletion rates over this 3 year study period, the increase in the 1986 rate over the 1978, 1982, and 1983 rates at K45 is of concern. The threat to lake whitefish, lake trout and possibly lake herring (DesJardine and Lawrence, 1978; Evans, 1978; DesJardine, 1980; Willox, 1982; Waring, 1986) is still present. Also of concern is the possibility of initiating a perpetual cycle of phosphorus release from bottom sediments if dissolved oxygen levels in bottom waters decrease further (Humber, 1985; Lake Sub-group, 1985).

Table 6: Dissolved oxygen depletion rates (mg/l/day) and mean hypolimnetic temperatures at K45, 1978 to 1986 (n = number of observations)

Year	n	Dissolved oxygen depletion rate (mg/l/day)	Mean hypolimnetic temperature (°C)
1986	12	-.09755	8.15
1985	15	-.08319	8.987
1984	17	-.08719	8.718
1983	7	-.05855	
	8		9.03
1982	7	-.06137	
	8		7.56
1981	7	-.0801	9.75
1980	12	-.08708	9.36
1979	5	-.07744	9.7
1978	5	-.05848	8.16

5.0 Recommendations

The Lake Simcoe Fisheries Assessment Unit should continue to monitor dissolved oxygen levels and temperatures at the 3 stations, K45, K42 and S15. Alternative methods of studying the relationship between dissolved oxygen levels and hypolimnetic temperature should be considered. The working relationship which has been established between the Ministry of Natural Resources Lake Simcoe Fisheries Assessment Unit and the Ministry of the Environment has facilitated the study of water quality in Lake Simcoe, and should continue. Current measures to control and decrease phosphorus inputs to the lake should also continue.

6.0 Acknowledgements

Special thanks is given to Ron Allen and Jack Lawrence for their help in collecting data, to Tim Rance and Cam Willox for their guidance and suggestions on report writing, and to Jan Street for her computer skills and diligence.

Thanks also to the Ministry of the Environment for providing the funding for one employee to carry out the limnology studies on Lake Simcoe. This cooperation between the M.O.E. and M.N.R. has proved to be a great asset and will hopefully continue in the future. The Lake Simcoe Region Conservation Authority has also been very helpful with administrative responsibilities on this project.

7.0 Bibliography

Birge, E.A. 1897. Plankton studies on Lake Mendota II. The Crustacea from the plankton from July 1894, to December 1896. Trans. Wis. Acad. Sci II: 274-448.

DesJardine, R.L. 1980. The dissolved oxygen and temperature regimes of Lake Simcoe during the summer of 1979. Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources. Report 80-2. 53p.

DesJardine, R.L. and J.N. Lawrence. 1978. The dissolved oxygen and temperature regimes of Lake Simcoe during the winter and summer of 1978. Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources. Report 78-5. 70p.

Dobson, J.E., R. Shaw, K.H. Nicholls, and M.B.Jackson. 1982. Water quality characteristics of Lake Simcoe 1980. Ontario Ministry of the Environment. 97p.

Evans, D.O. 1978. An overview of the lake whitefish, Coregonus clupeaformis (Mitchell) in Lake Simcoe, Ontario. Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources. Report 78-1. 132p.

Franson, M.A. (Ed) 1975. Standard methods for the examination of water and waste water. 14th edition. American Public Health Association. Washington, D.C. 1193p.

Humber, J.E. 1985. Water Quality Charateristics of Lake Simcoe 1980-1984. Lake Simcoe Environmental Strategy Report B1.

Lake Sub-group. 1985. Overview of Lake Simcoe Water Quality and Fisheries Studies. Lake Simcoe Environmental Strategy Report B.

Ralston, J.G., S.M. Irwin, and D.M. Veal. 1975. Lake Simcoe basin, a water and use study. Ontario Ministry of the Environment. Water Resources Branch, Toronto. 143p.

Waring, P. 1986. Dissolved oxygen and temperature profiles at two Lake Simcoe limnological stations 1981-1983. Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources. Report 1986-2. 42p.

Willox, C.C. 1982. The dissolved oxygen and temperature regimes of Lake Simcoe during the summer of 1980. Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources. Report 82-1. 47p.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall Inc., Englewood Cliffs, N.J. 620p.

8.0 Appendices

Appendix A: Data used in analyses of variance to test for differences between mean hypolimnetic temperatures when comparing sites and years [n=number of observations, x=hypolimnetic temperature (°C)]

Year	Site	Σx	Σx^2	n	$\bar{x}$
1984	K45	148.2	1310.12	17	8.718
	K42	133.9	1131.71	16	8.369
	S15	128.7	1608.33	11	11.700
1985	K45	134.8	1242.66	15	8.987
	K42	114.7	1035.27	13	8.823
	S15	148.0	2004.00	11	13.454
1986	K45	97.8	812.96	12	8.150
	K42	102.2	819.42	13	7.861
	S15	136.5	1897.39	10	13.650

Appendix B: Data used in analyses of covariance to compare summer dissolved oxygen depletion rates (mg/l/day) of the 3 sites over the 3 year study period (n=number of observations, x=number of days since June 1, y=dissolved oxygen level (mg/l/day) at 5 m. above bottom for K45 and K42, and 3m above bottom for S15)

Year	Site	$\Sigma x^2 - \frac{(\Sigma x)^2}{n}$	$\Sigma xy - \frac{\Sigma x \Sigma y}{n}$	$\Sigma y^2 - \frac{(\Sigma y)^2}{n}$	n
1984	K45	28770.12	-2528.506	227.18	17
	K42	23937.44	-2079.93	185.049	16
	S15	11680.917	- 919.117	77.217	12
1985	K45	18772.0	-1561.7	136.284	15
	K42	21998.858	-1846.814	158.289	14
	S15	7690.917	- 560.042	52.069	12
1986	K45	17214.92	-1679.4	166.92	12
	K42	16538.77	-1528.3	144.74	13
	S15	6505.6	- 591.76	58.456	10

Appendix C: Data used in analysis of covariance to compare summer dissolved oxygen depletion rates (mg/l/day) from 1978 to 1986 at K45 (n=number of observations, y=hypolimnetic dissolved oxygen level (mg/l), x=days from June 1)

Year	$\Sigma x^2 - \frac{(\Sigma x)^2}{n}$	$\Sigma xy - \frac{\Sigma x \Sigma y}{n}$	$\Sigma y^2 - \frac{(\Sigma y)^2}{n}$	n
1986	17214.92	-1679.4	166.92	12
1985	18772.0	-1561.7	136.284	15
1984	28770.12	-2528.506	227.18	17
1983	12554.19	- 735.13	47.97	7
1982	10889.4	- 668.23	41.69	7
1981	10951.7	- 877.19	71.25	7
1980	15866.9	-1381.7	126.08	12
1979	9215.2	- 713.64	55.808	5
1978	4456.0	- 260.6	19.998	5

Appendix D: Data used in analysis of variance to test for differences between the mean hypolimnetic temperatures (°C) of 1978 to 1986 at K45 (n=number of observations, x=hypolimnetic temperature °C)

Year	Σx	Σx^2	n	$\bar{x}$
1986	97.8	812.96	12	8.15
1985	134.8	1242.66	15	8.987
1984	148.2	1310.12	17	8.718
1983	63.2	594.78	7	9.03
1982	60.6	493.71	8	7.56
1981	78.0	791.04	8	9.75
1980	112.3	1064.99	12	9.36
1979	48.5	447.13	5	9.7
1978	40.8	336.2	5	8.16